About the contributors

Paul Boyer joins 33 other authors to tell the story of the Pre-Engineering Education Collaborative (PEEC) experiment in four states: Hawai'i, North Dakota, South Dakota, and Wisconsin involving 17 colleges and universities. With the goal of bringing engineering education to Native Americans and Native Hawaiians, the seven-year ongoing NSF-funded project included five Native Hawaiian-serving community colleges and six tribal colleges, each partnering with at least one of six mainstream State universities. A thirty-four person PEEC Book Advisory Council, including members from 16 of the 17 PEEC institutions, provided guidance for authors with PEEC experience who write about their successes, challenges, best practices, recommendations, and hopes for the future.

The authors share experiences for the benefit of practitioners of PEEC, for those who provided funding, and for would-be practitioners who may be interested in bringing engineering education to Native Hawaiians, Native Americans, under-represented groups, and students everywhere. It is our hope that readers gain insights that help foster the intent of the unique PEEC program long into the fut

Photo: North Dakota PEEC summer camp opening ceremonies at NDSU. At left, G. Padmanabhan, Professor of Civil and Environmental Engineering, NDSU; with Robert Pieri (wearing a star quilt), Professor of Mechanical Engineering, NDSU. Pieri serves as NDSU PI for the ND PEEC, and Padmanabhan as the Co-PI.
(Photo credit: Lane Azure)

PEEC INSTITUTIONS:

Hawai'i
Kapi'olani Community College
Honolulu Community College
Leeward Community College
Maui College
Windward Community College
University of Hawai'i System
University of Hawai'i at Manoa

North Dakota
Cankdeska Cikana Community College
Nueta Hidatsa Sahnish College
*Sitting Bull Community College
Turtle Mountain Community College
North Dakota State University

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

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

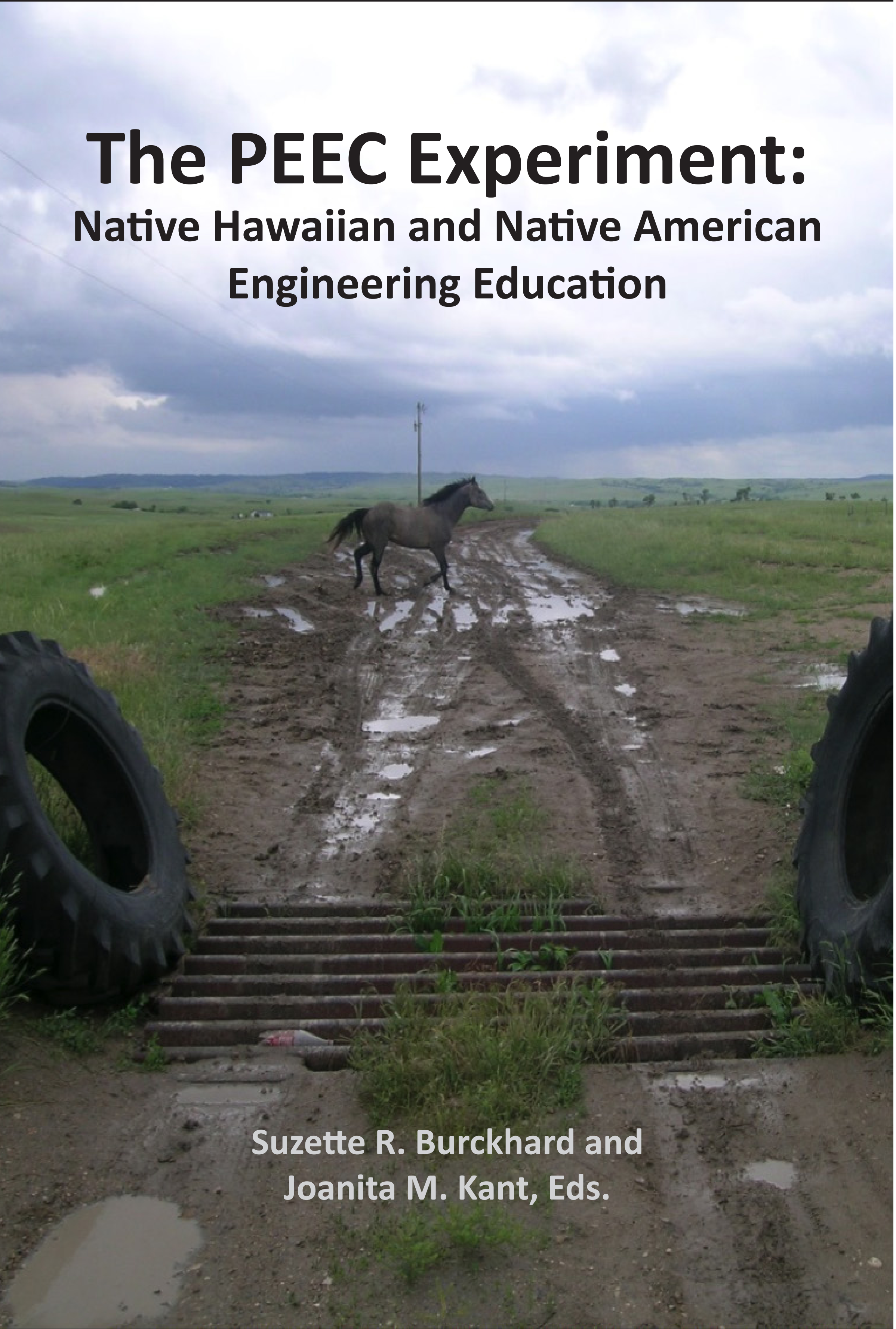
*All institutions have PEEC Book Advisory Council members and/or authors with the exception of Sitting Bull Community College.

The PEEC Experiment

Burckhard and Kant, Eds.

The PEEC Experiment:

Native Hawaiian and Native American Engineering Education



Suzette R. Burckhard and
Joanita M. Kant, Eds.

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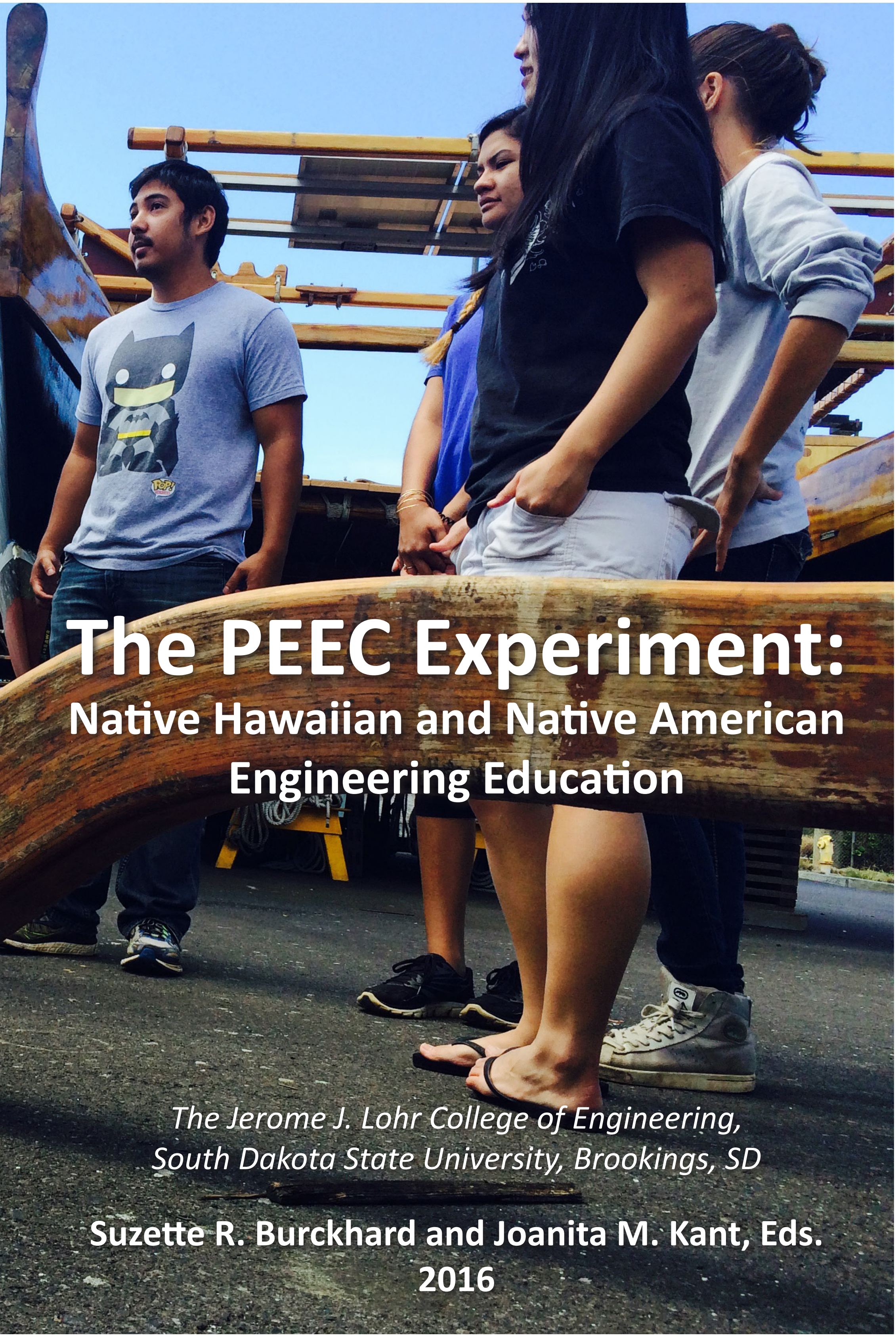
Cover photo: Horse in a thunderstorm on Pine Ridge Reservation, SD, in a PEEC project area in 2012. Cattle guards such as this one dot the landscape. They are designed to keep split-hoofed livestock, such as cattle, from crossing. (Photo credit: Joanita Kant)

Photo: Hawai'i students at the Marine Education Training Center studying vessels, including a double-hulled voyaging canoe. (Photo credit: Hannah Aldridge)



The PEEC Experiment:

Native Hawaiian and Native American Engineering Education

The Jerome J. Lohr College of Engineering,
South Dakota State University, Brookings, SD

Suzette R. Burckhard and Joanita M. Kant, Eds.
2016

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FOREWORD

In September 2010, the National Science Foundation (NSF) began funding what became a multi-year Pre-Engineering Education Collaborative (PEEC) with twelve grant awards totaling millions of dollars to 17 institutions in four states: Hawaiʻi, North Dakota, South Dakota, and Wisconsin. The NSF funded PEEC through two directorates: (1) the Directorate for Education and Human Resources/Division of Human Resource Development (EHR/HRD) within Tribal Colleges and Universities (TCUP), and (2) the Engineering Directorate. The overarching purpose was to bring engineering education to Native Hawaiians and Native Americans. Within PEEC, six mainstream state universities collaborated with community colleges as leaders including five that are Native Hawaiian-serving and six that are tribally-controlled. Those include the following with mainstream universities italicized:

HAWAIʻI
UH-Kapiʻolani Community College
UH-Honolulu Community College
UH-Leeward Community College
UH-Maui College
UH-Windward Community College
University of Hawaiʻi at Mānoa
University of Hawaiʻi System

NORTH DAKOTA
Cankdeska Cikana Community College
Nueta Hidatsa Sahnish College
Sitting Bull College
Turtle Mountain Community College
North Dakota State University

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

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

PEEC goals included delivering to Native Hawaiian and Native American students, the first two years of a Bachelor of Science degree program in engineering at the community college level, coupled with smooth transitioning to collaborating four-year mainstream engineering schools.

As a logical extension of the overall PEEC initiative, project leaders produced this book to disseminate overall findings and to facilitate communication between all 17 participating PEEC institutions. Those leaders worked together in teams as co-authors of chapters to synthesize and report insights, outcomes, and best practices. After nearly seven years of NSF-funded PEEC research; faculty, staff, and students documented Native-Hawaiian and Native American tribally-specific information that is potentially scalable for Native-serving institutions and mainline university collaborators.

For whom is the book written? It is for PEEC participants to share their experiences and learn about best practices and recommendations. It is a place for them to share what worked. It also provides a starting point for other colleges serving indigenous populations and for the mainstream colleges and universities with whom they might collaborate in a model pre-engineering program. Insights developed from PEEC have particular applicability for populations in poverty and for indigenous populations as a matter of social justice.

Authors, representing a few PEEC schools have formally published individual, preliminary results in various journals and proceedings. The book is rooted in those publications, but it is also a means of generating similarly useful data from those PEEC writers who have previously not published.

By bringing engineering to Native Hawaiians and Native Americans, both the engineering profession and society benefit from the wider variety of cultural perspectives. Having built capacity through PEEC, Native Hawaiian-serving community colleges and tribal colleges are now in a better position to bring engineering to Natives, severely underrepresented in the Engineering profession. These are their stories.

Suzette R. Burckhard and Joanita M. Kant, Editors,
December 2016

ACRONYMS

AA	Associate of Arts
ABET	Accreditation Board for Engineering & Technology
AIAN	American Indian / Alaska Native
AIHEC	American Indian Higher Education Consortium
AIM	Assessment of Institutional Map (survey)
AMP	Alliance for Minority Participation
ANLSAMP	All Nations Louis Stokes Alliance for Minority Participation
ArcGIS	Aeronautical Reconnaissance Coverage Geographic Information System
ARI	Academic Research Infrastructure
ARM	Alliance for Responsible Mining
ASEE	American Society for Engineering Education
ASNS	Associate in Science in Natural Science (degree)
AZ	Arizona
BIA	Bureau of Indian Affairs
BIE	Bureau of Indian Education
BS	Bachelor of Science
BHSU	Black Hills State University
CA	California
Cansat	(a rocket used to teach space technology)
CAHPO	Cultural Affairs and Historical Preservation Office (of OST)
CAO	Chief Academic Officer
CCCC	Cankdeska Cikana Community College
CDC	Community Development Corporation
CMN	College of Menominee Nation
CNA	Certified Nursing Assistant
COE	College of Engineering
CSC	Chadron State College
DBH	Defenders of the Black Hills
DRA	Dakota Rural Action
EIT	Erdenet Institute of Technology
EPICS	Engineering Projects in Community Service
EPP	Environmental Protection Program (of OST)
EPSCoR	Experimental Program to Stimulate Competitive Research
EROS	Earth Resources Observation and Science
FBCC	Fort Berthold Community College
FIRE-UP	Faculty Integration of Research and Education in Urban Polynesia
FIS	Flandreau Indian School
GEAR UP	Gaining Early Awareness and Readiness for Undergraduates Program
GED	General Educational Development (test) when passed provides certification of high school level skills
GIS	Geographic Information System
GPS	Global Positioning System
HI	Hawai‘i
HCC	UH-Honolulu Community College
HUD	Housing and Urban Development (US)
HDLM	Hybrid Distance Learning Model
IACUC	Institutional Animal Care and Use Committee
IBC	Institutional Biosafety Committee

IRB	Institutional Review Board
ISL	*in situ* leach (e.g., uranium mining)
IVN	Interactive Video Network
K-12	Kindergarten through 12th grade
KCC	UH-Kapi‘olani Community College
KS	Kamehameha Schools
LCC	UH-Leeward Community College
MC	UH-Maui College
MIE	Model Institute of Excellence [Department]
MIT	Massachusetts Institute of Technology
MOP	Marine Option Program
MST	Math, Science &Technology (Department at OLC)
MSU	Montana State University
NA	Native American
NAE	National Academy of Engineering
NASA	National Aeronautics and Space Administration
NASA-SEMAA	National Aeronautics and Space Administration -Science and Engineering Mathematics and Aerospace Academy
NASHI	Native American Sustainable Housing Initiative
NATURE	Nurturing American Tribal Undergraduate Research and Education
NCAI	National Conference of American Indians
ND	North Dakota
NDSBHE	North Dakota State Board of Higher Education
NDSU	North Dakota State University
NDUS	North Dakota University System
NGT	Nominal Group Technique
NH	Native Hawaiian
NHSC	Nueta Hidatsa Sahnish College
NIFA	National Institute of Food and Agriculture
NNRC	Northwest Nebraska Resource Council
NRRA	Natural Resources Regulatory Agency (of OST)
NSF	National Science Foundation
nN	non-Native
OFIE	Office for Institutional Effectiveness (at KCC)
OHA	Office of Hawaiian Affairs
OHRP	Office of Human Research Protections
OLC	Oglala Lakota College
ONR	Office of Naval Research
OSSPEEC	Oglala Lakota College, South Dakota State University, South Dakota School of Mines & Technology Pre-Engineering Education Collaborative (i.e., the South Dakota PEEC)
OST	Oglala Sioux Tribe
OST EPP	Oglala Sioux Tribe Environmental Protection Program
OST NRRA	Oglala Sioux Tribe Natural Resources Regulatory Agency
PEEC	Pre-Engineering Education Collaboratives
PI	Principal Investigator
PTiPS	Pipeline for Tribal Pre-Engineering Society
REU	Research Experiences for Undergraduates
RESPEC	(An integrated consulting services firm related to mining and engineering)
RIG	Research Initiation Grant
RRB	Research Review Board

RSI	Rural Systemic Initiative
SBC	Sitting Bull College
SD	South Dakota
SDSMT	South Dakota School of Mines and Technology
SDSU	South Dakota State University
SEE	Summer Engineering Experience (1, 2, or 3)
SEM	Science, Engineering, and Math
SENCER	Science Education for New Civic Engagements and Responsibilities
SMC	Sioux Manufacturing Corporation
STEaM Girls	Science, Technology, Engineering, art, and Math Girls
STEM	Science, Technology, Engineering and Math
SURF	STEM Undergraduate Research Fair
TA	Teaching Assistant
TCC	Tribally Controlled College
TCJ	Tribal College Journal
TCCCAA	Tribally Controlled Community College Assistance Act
TCU	Tribal College/University
TCUP	Tribal Colleges and Universities Program
Title III	(a US Federal grant program to improve education)
TMCC	Turtle Mountain Community College
TRiO	TRiO is not an acronym. It is a group of Federal education outreach programs implemented by the US Department of Education
UC	University of Colorado (Boulder)
UH	University of Hawai‘i
UH-M	University of Hawai‘i at Mānoa
UH-M COE	University of Hawai‘i at Mānoa College of Engineering
UM	University of Michigan
URE	Undergraduate Research Experience
USDA	United States Department of Agriculture
US EPA	United States Environmental Protection Agency
UTTC	United Tribes Technical College
UW-M	University of Wisconsin-Madison
UW-P	University of Wisconsin-Platteville
WCC	UH-Windward Community College
WI	Wisconsin

Sarah Paquette of the Chemistry faculty observes an experiment with Charles James, Sr. In 2013, James became the College of Menominee Nation's (CMN's) first engineering graduate with an Associate of Arts in Material Science and Pre-Engineering. James continued his studies at CMN's partner institution, the University of Wisconsin-Madison. (Photo credit: CMN by DKakkak)

Part I: Context

1.

Engineering for Native nations: Origins and goals of the Pre-Engineering Education Collaboratives (PEECs)

Paul Boyer

INTRODUCTION

Since the founding of the first colonial settlements in Virginia and New England, Native Americans have been encouraged and, at times, compelled to attend schools created by Europeans. Indeed, some of the very first colleges founded in the seventeenth century, including The College of William and Mary, and Harvard College, made the education of Native Americans a part of their missions. However, the purpose of this schooling was not to strengthen and sustain Native societies. Rather, it was expected to weaken and destroy them. For 500 years, education was part of a larger effort to assimilate Native Americans into the dominant society. Schools told students to forget their languages, reject their cultures, and learn skills valued in the dominant economy.

Not all Native Americans opposed this schooling. A small number willingly enrolled and a few even graduated. In 1665, Caleb Cheeshahteaumuck, a member of the Wampanoag Tribe from Martha's Vineyard, was the first Native American to graduate from Harvard College. But, despite the urgent wishes of colonists, few followed his example. When the Jamestown settlers were berated by their European backers for not doing more to educate the Native population, Governor George Yeardley replied in 1621 that, "The Spirituall vine you speak of will not so sodayny be planted as it may be desired, the Indians being very loathe upon any tearmes to part with theire children" (Szasz, 1974, p. 57). And more than a hundred years later, an Onondoga leader named Canassatego, politely, but firmly, refused an offer to send children of his tribe to the College of William and Mary. “The Indians,” he said, “are not inclined to give their Children learning. We allow it to be good but our Customs differing from yours, you will be so good as to excuse us” (Van Doren, 1938, p. 76).

This opposition to schooling at all levels continued well into the twentieth century. In 1925, Navajo tribal leader Chee Dodge wrote a letter complaining that enrollment of Native American children in government schools directly weakened the tribe’s subsistence-based agricultural economy by removing children from their traditional role as shepherds. He asserted that,

> *Attempts are being made to take children of all ages even up to 20 years to school, but I am afraid this idea of forcing children will not work out satisfactorily. You know well enough how many children have run away from Ft. Apache [boarding school] in the past and further I believe you will realize that by taking these older children the sheep industry of the Navajos will suffer greatly.* (Iverson, 2002, p. 90)

What Dodge and other tribal members knew was that education was not simply unpleasant and often abusive. Resistance also reflected an understanding that schooling harmed the social and economic structures of traditional Native societies. Children who were absorbed into the school system were lost to families and tribes, in nearly every sense. From this perspective, opposition to western education was not ignorance or stubbornness; it was a strategy for survival.

SELF DETERMINATION, TRIBAL COLLEGES, AND THE SEARCH FOR RELEVANCE

Attitudes toward education began to shift, however, reflecting larger changes taking place in the nation and the world. In the closing days of World War II, the Navajo tribal council signaled the new era when it passed a resolution requesting that the federal government provide *more* schooling for their children. Arguing that the tribe was handicapped by “poverty, poor health, limited resources, inability to speak English, and lack of training to improve our condition.” The resolution asserted that, “our people are realizing that education like the white man’s is needed to learn better farming, to learn how to improve livestock, to learn to improve health, and to learn new trades” (Iverson, 2002, p. 191). Higher education also emerged as a priority in reservations across the country and by the early 1950’s several tribes were funding their own scholarship programs.

Attitudes changed not because tribal members were embracing assimilation. Instead, formal schooling became a priority because leaders hoped that, through education, they could take charge of their own communities. By learning how to manage their tribal reservations, which many were now calling tribal *nations*, they could fight the federal government's efforts to terminate their tribal status (which was the policy goal of Congress in the 1950's) and provide more employment options for tribal members at home. For the first time, education was viewed as part of a larger agenda for tribal survival.

By the 1960's, this growing faith in empowerment through education was reinforced by an even more "radical" position that Indians should have a role in controlling the kind of education they received. In this era, numerous colleges and universities created American Indian studies programs and funded Indian Centers as a way to provide space for Native American students, both physically and intellectually, within otherwise inhospitable institutions. Led by a cadre of young Native American academics, these degree programs and centers acted as safe havens for Native American students, forums for discussion of Native American policy, and—it was hoped by their leaders—beachheads from which broader institutional reforms could be promoted (Boyer, 2015, p. 10).

Significantly, this movement also led to the founding of the first tribally controlled colleges. These institutions of higher learning were founded by Native Americans and chartered by tribes. In most cases, they were located on reservations, built on the movement for greater self-determination by not only making education responsive to the needs of Native Americans, but also placing it under their control. The first, established by the Navajo Nation in 1968, was quickly followed by institutions in California and the northern Plains. Most followed the community college model and provided certificates and two year degree programs leading to local employment or continued study at mainstream universities.

Building renewed respect for culture was also an integral part of each tribal college's mission. Rejecting centuries of assimilationist rhetoric, they argued that Native American societies struggled not because they retained their culture, but because they were losing their culture. To move forward, they needed to restore a sense of pride in their heritage and in the values that had nurtured and sustained their societies for millennia. Tribal college students could study the language, history, art, and philosophy of their tribe—and also see cultural values reflected across campus.

EXPLAINING THE STEM ENROLLMENT GAP

As more Native American and Native students came to view college as both accessible and meaningful, enrollments began to climb. In 1935, there were, according to one survey conducted at the time, only 52 Native American college graduates in the entire United States. By the late 1950's, however, the estimated enrollment had climbed to 2,000 (Beck, 1995, p. 6-7). Rapid growth continued in the following decades. Nationwide, the number of Native Americans and Alaska Natives with college degrees doubled from 1976 to 2006, reaching a total enrollment of over 180,000 (National Center for Education Statistics, 2008a). For a variety of reasons, statistics related to Native American college enrollment and retention are highly variable, but these numbers clearly show a strong upward trend.

However, the legacy of limited expectations remains. While college participation has grown dramatically, it still lags the nation as a whole. Native Americans are still the most underrepresented group in America's colleges and universities, and they remain the most likely to drop out. Reviewing available statistics, Patterson, et al. concluded that Native American and Alaska Native students "who get a high school diploma and begin attending a public college have the highest dropout rate compared to any other student population, despite being academically capable" (2015, p. 3).

It is not surprising, therefore, that Native Hawaiians, Native Americans, and Alaska Natives are also underrepresented in engineering degree programs. In 2012, for example, only 355 Native Americans graduated with baccalaureate degrees in engineering, out of more than 87,000 engineering degrees awarded that year, according to data collected by the National Science Foundation (2015). While total enrollment in engineering programs is climbing robustly, Native American enrollment shows, at best, only a slight upward trend in recent years.

This disparity exists contrary to the wishes of educators in engineering disciplines. The American Society for Engineering Education (ASEE), for example, in its Statement on Diversity and Inclusiveness, asserts that, "engineering must actively engage and help promote the pursuit of engineering education and engineering careers with those individuals who have been historically under-represented within engineering" (ASEE, 2016, n. p.). Yet the problem of low Native American enrollment in engineering and other STEM fields is not easily solved. Goodwill and good intentions are easily thwarted by a complex set of barriers that discourage Native

Americans from considering STEM careers and blocking their progress if they try. These barriers include the following.

A perception that Native Americans “can’t do” math and science
Native educators often report, for example, a persistent belief within their communities that mathematics and science are “non-Indian” disciplines and somehow beyond their capacity to master at a high level. It is an unsupportable argument; mathematics, engineering, and the methods of scientific observation were, in fact, integral parts of indigenous societies long before the arrival of Europeans. However, the belief was long reinforced by some educators, that Native Americans, as a group, somehow live outside the disciplines of mathematics and science. As recently as the late 1960’s, Native American students were openly discouraged from pursuing careers in science-based fields such as medicine, on the argument that it was too hard and they would fail. It is not surprising that their children and grandchildren have also internalized, at some level, the feeling that mathematics and science are not only inhospitable, but also inapproachably difficult.

Poor academic preparation
Reinforcing these attitudes are longstanding weaknesses in the quality of K-12 education provided to many Native American students. Nearly 50 years ago, for example, the influential “Kennedy Report” on Native American Education, released by the Senate Subcommittee on Indian Education, attacked the “low quality of virtually every aspect of schooling available to Indian children” (United States Senate, 1969, p. xii*).* Over 20 years later, the *Indian Nations at Risk* report similarly charged that, “our schools have failed to nurture the intellectual development and academic performance of many Native children” (U. S. Department of Education, 1991, p. 1). More recently, the decades-old school reform movement continues to spotlight disparities in the depth and variety of mathematics and science courses offered to Native students. All studies argue that poorly prepared students are less likely to attend college or to successfully earn a degree.

Limited awareness of engineering
Compounding negative attitudes and lack of academic preparation is lack of familiarity with many STEM-related careers. Native educators consistently note that many community members have never met an engineer, and they likely have no idea what engineers do. While there are now Native role models in other professions—such as nursing and teaching—numerous tribes do not yet have a single tribal member working in an engineering field. Lost in the shadows, engineering is, in many cases, not “rejected” by Indian students; instead, it is simply not seen.

These problems represent a systemic barrier faced by Native American and Native children as they contemplate college and their future careers. They suggest that recruitment of Native students into engineering requires more than an open door. Instead, it must be part of a larger and sustained effort to address systemic barriers to their academic success.

ENGINEERING, TRIBAL NATION BUILDING, AND THE QUESTION OF RELEVANCE

Strategies based on outreach, recruitment, and K-12 reform, while important, may not be enough. While barriers to education must be removed, the centuries-old question of relevance still resonates. More than opportunity, students need a reason to pursue STEM degrees. This is true for all college students, who want to know that their time and money will not be wasted. But for many Native students, there is also a strong desire to do more. Within tribal colleges, for example, students consistently say they are motivated by a desire to strengthen their communities, both socially and culturally. Many students want to know that they will not only be employable, but that they will be able to use skills for the betterment of their tribal nations.

Without question, STEM is now the nation's highest educational priority, elevated above other disciplines because it is viewed as a driving force in the nation's economy. Federal and state-level efforts to increase participation in mathematics and science-related fields reflect a belief that America is "falling behind" other nations, especially those viewed as economic or military competitors. This perceived gap is presented as an issue of national security. "Reaffirming and strengthening America's role as the world's engine of scientific discovery and technological innovation is essential to meeting the challenges of this century," said President Obama, announcing his *Educate to Innovate* initiative early in his presidency (White House website, November 23, 2009, n.p.). Among the specific goals established was, according to a White House statement at the time, "improving the quality of math and science teaching so American students are no longer outperformed by those in other nations."

Educators, too, use this kind of rhetoric because it has political traction. But appeals to national power and economic competitiveness on a world stage are, in the end, political rationales that flatten and distort the role of education in society. Furthermore, they probably have little bearing on the educational choices of most students--including those living on reservations, where the phrase "challenges of this century" might bring to mind the more tangible problems of substandard housing, contaminated soil and water, poor nutrition, substance abuse, and reservation unemployment rates climbing to 60, 70, or 80 percent. When contemplating the value of education, many Native Hawaiians, Native Americans, and Alaska Natives forcefully say that they want to pursue a degree that can directly address these concerns.

THE NSF AND THE PRE-ENGINEERING EDUCATION COLLABORATIVES

In 2005, several administrators within the National Science Foundation (NSF) came together to address the problem of low enrollment in engineering among Native Hawaiians, Native Americans, and Alaska Natives. One was Michael Reischman, then NSF's deputy assistant director of engineering, who, through his own professional experiences at laboratories and universities in New Mexico and Oklahoma, had long-standing interest in the educational needs of Native American students. The other key player was Jody Chase, program director in the NSF's Tribal Colleges and Universities Program (TCUP) which, since its establishment in 2000, supported the development of STEM programs within tribal colleges and several Native serving mainstream universities. Chase was also responsible for attracting several experienced tribal college educators to work at the NSF, including Carty Monette, past president of Turtle Mountain Community College in North Dakota, who also helped guide the project. Stacy Phelps, a faculty member at Oglala Lakota College, was also instrumental in shaping early interest within the NSF, and helped organize a key planning meeting in 2005.

From the outset, it was understood that the problems of low enrollment and retention in engineering degree programs could not be solved by mainstream universities alone. While many colleges of engineering expressed a desire to enroll Native American engineering students, their efforts too often came up short, argued Reischman: "Their rhetoric was always the same." Reischman said that Indians were welcome, but, "in practice, did they do the key things on their campuses to make that happen? No. Sure they enrolled [some Native American students]; they enrolled the absolute best . . . , and their chance of graduating was still about 50 percent." Additionally, mainstream universities were often perceived by Native American students as distant and intimidating institutions.

It was equally unrealistic to ask tribal colleges to bear full responsibility for development of engineering degree programs. While they excel at serving the needs of Native students, most tribal colleges are small—enrollments range from a few hundred to just over a thousand, in most cases—and have correspondingly limited resources. Furthermore, many tribal colleges were still developing their core mathematics and science programs (often with support from NSF). While a few offered a limited number of four year degrees and some were adding graduate programs (typically in education, business, and the biological sciences), all remained focused on two year degree programs. None had an engineering program and, considering their limitations, few were capable of adding their own program any time in the near future.[1]

The solution, developed in consultation with tribal college educators at a key 2005 planning meeting, was to combine the strengths of both mainstream universities and tribal colleges. Several models were proposed, but, in the end, "it became obvious that the endgame was development of a [two-year] pre-engineering curriculum" within the tribal colleges, recalled Reischman, leading to enrollment in a four year degree program at a partnering mainstream university. This approach acknowledged the strengths of both Native-serving colleges and mainstream institutions. Tribal colleges could focus on recruiting Native Americans into engineering and building core math and science skills. Mainstream universities could provide the expertise and resources needed to complete upper division coursework.

In earlier eras, funding for projects of this sort was typically awarded to mainstream universities, with tribal colleges being viewed (and treated) as junior partners. This approach was rejected by Reischman and Chase, who agreed that awards would be made to tribal colleges. Serving as the lead institutions, the Native-serving colleges could establish a coherent vision for a pre-engineering degree program, and identify one or more mainstreams university partners. Chase sent out a solicitation—"And then it came down to a careful choice," she said. In the end four proposals were funded under the Pre-Engineering Education Collaboratives (PEECs), representing seventeen institutions located in North Dakota, South Dakota, and Wisconsin. Each collaborative was, in turn, supported by at least one mainstream university partner. In addition, the initiative also included five of Hawaiʻi's community colleges, and the mainstream University of Hawaiʻi at Mānoa.
While tribal and community colleges were the lead institutions, the centerpiece of the Pre-Engineering Education Collaboratives was its focus on building what Reischman called "substantial and meaningful partnerships"

between Native serving and mainstream institutions. Tribal colleges, for

[1] One exception is Salish Kootenai College on the Flathead Reservation, which started developing its own four-year computer science degree program with support from NASA around this time.

their part, had a responsibility to prepare students for the rigorous academic requirements of engineering programs. Mainstream institutions, meanwhile, needed to support program development within the tribal colleges. They also needed to help students make a successful transition into their institutions, and to offer on-going support after enrollment. Both Native serving and mainstream universities needed to cooperate on development of these vital recruitment, retention, and enrichment programs.

PEEC and the relevance of engineering

How the various programs were created and what they accomplished is the focus of this book, and the following chapters provide detailed examinations of each collaborative in Hawai‘i, North Dakota, South Dakota, and Wisconsin. Collectively, however, it is clear that all have met the key objectives of the initiatives. In every case, tribal colleges and community colleges within the University of Hawai‘i system have successfully established pre-engineering degree programs. Additionally, the PEECs also developed and refined innovative approaches to student recruitment, academic support, and retention. As many of the following chapters discuss, strategies included bringing tribal and Native students onto mainstream campuses for summer enrichment experiences, experimenting with student cohort models, offering focused remediation in mathematics, and bringing mainstream university faculty to tribal and Native Hawaiian serving ands tribal colleges. In these ways, the goals of PEEC were fully met.

But the PEECs have actually accomplished a great deal more. Beyond immediate program development goals, they are changing how Native students think about engineering and its role in their own communities. Some tribes manage a land base larger than several states, and all have the responsibility to oversee natural resources, maintain a sprawling infrastructure (e.g., roads, buildings, and dams), and also participate in the increasingly global economy. Yet, prior to PEEC, most did not have a single tribal member with an engineering degree. Six years later, however, all colleges participating in PEEC have enrolled students in their pre-engineering programs and most watched students continue their studies at partnering four-year institutions. Numbers are sometimes small because colleges are small and most serve very small tribes. But this makes the presence of even one engineer all the more important. In many cases, these graduates are the pioneers, showing what can be accomplished.

Through PEEC, these students are discovering that engineering can, in fact, help address the most pressing social, cultural, and economic issues facing their communities. The practical application of engineering is reflected in a project-based curriculum that is the centerpiece of most of the degree programs. Even during the first semester of study, students have worked to build affordable homes, design wind turbines, and examine the environmental impacts of mining and gas drilling operations, to cite a few of the hands-on projects that will be discussed in the following pages. These activities are not simply academic exercises; they provide tangible benefit to their communities and also demonstrate the power of engineering to build healthier, more livable communities. Proving that engineering is an integral part of tribal nation-building may be, in fact, the most important and most durable impact of the initiative. This awareness is long overdue.

According to Alan Cheville, a former program director at the NSF, who now serves as chair in electrical and computer engineering at Bucknell University, the concepts of “relevance” and “service” are central to the disciplines of engineering. Speaking at a 2014 PEEC networking workshop in Minneapolis, he observed that “context is everything in the execution of a project,” requiring close consideration of local conditions and the needs of the local community. It is a pragmatic observation with profound implications for Native American education where, for nearly 500 years, local context was believed to be irrelevant, and failure was viewed to be the fault of students, not institutions. In contrast, PEEC reflects a “ground up” approach to engineering education that fully address the needs and concerns of the people it serves. And through PEEC, tribal colleges and other Native serving colleges, working with their mainstream university partners, now have another way to help rebuild the foundation of tribal nations and to repair the fabric of Native societies.

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North Dakota PEEC students visit Northrup Grumman's New Town site. (Photo credit: Lori Alfson)

PART II: Culture matters

2.

Recognizing history: Indigeneity matters

Richard Meyers (SD), Wiyaka His Horse Is Thunder (SD), and Alaina Hanks (SD)

INTRODUCTION

> *There is no universally accepted description or definition of indigenous peoples. But whether they are called indigenous, autochthonous, tribal, or Fourth World of First Nations, there is a growing consensus about them and their continuing plight. Their own perception of themselves combined with the historical fact of being the descendants of the original inhabitants of the lands where they live is enough for anyone to get a fairly precise idea of the subject . . .* (Independent Commission on International Humanitarian Issues, 1987, p. xiv).

Long before waves of immigrants arrived on the scene in what later became the United States of America, indigenous populations were present and existing in highly complex and advanced cultures. For example, Eric Wolf (1982), Edward Hall (1989), and Roxanne Dunbar-Ortiz (2014) have analyzed such non-European societies' interconnected and highly sophisticated economic and cultural systems. Included in these indigenous groups are Native Hawaiians (NHs) and Native Americans (NAs)—(although the federal, legal/official terminology for NAs is "American Indian or Alaska Native, AIAN," we will often employ NA in this writing as synonymous).

There are two major differences that set NHs and NAs apart from minorities, ethnic groups, and under-represented populations within the United States (US). The first is the relationship of NHs and NAs to the indigenous land base that they consider their homeland, thus, nullifying their assignment to the categories of “immigrant” or “minority” in the sense that those terms are used for other special interest groups. The second is the concept of sovereignty which was the case for both groups historically and which remains the case for NAs on reservations today. There are currently 567 federally recognized tribal governments that work directly with the US government and not with the State that surrounds their respective NA territory. A good place to learn about the relationship of the tribes to the Federal government is the Bureau of Indian Affairs’ (BIA’s) website (2016b). The following is a brief summary of sovereignty for NAs from the perspective of the US Federal government.

> *The United States has a unique legal and political relationship with Indian tribes and Alaska Native entities as provided by the Constitution of the United States, treaties, court decisions, and federal statutes. Within the government-to-government relationship, Indian Affairs provides services directly or through contracts, grants, or compacts to 567 federally recognized tribes with a service population of about 1.9 million American Indian and Alaska Natives. While the role of Indian Affairs has changed significantly in the last three decades in response to a greater emphasis on Indian self-governance and self-determination, Tribes still look to Indian Affairs for a broad spectrum of services. (BIA, 2016b)*

The relationship that the Unites States government maintains with NAs has been ongoing since the inception of the country. Originally located in the War Department, the BIA is the oldest bureau in the US Department of the Interior with its beginnings in 1824. Alongside the BIA, is a body of law that the US government has for its dealings with NAs. Native Hawaiians (NHs), however, do not share this relationship or legal status. Among some NHs, there is an evolving sovereignty movement encouraged by activists in Hawaiʻi but not without opposition. The following passage provides context for Federal Indian law and the relationship that tribes have with the US government.

> *Indian Law has always shifted back and forth with the flow of popular and governmental attitudes towards Indians. Yet a few themes have persisted and form the doctrinal bases of present law. At the risk of oversimplification, they may be reduced to four. First, the tribes are sovereign entities with inherent power of self-government. Second, the sovereignty of the tribes is subject to exceptionally great powers of Congress to regulate and modify the status of the tribes. Third, the power to deal with and regulate the*

> *tribes is wholly federal; the states are excluded unless Congress delegates power to them. Fourth, the federal government has a responsibility for the protection of the tribes and their properties, including protection from encroachments by the states and their citizens. (Canby, 2015, pp. 1-2)*

It is important to note that the status of NAs in the US is not shared by all indigenous populations across the hemisphere or globe. To clarify — the government-to-government trust responsibility that has legal backing is not necessarily the case for other nation states such as Mexico or those in Latin America at large. The legacy of colonialism on the indigenous populations across the globe is specific to each historical nation-state's relationship to its indigenous populations. Although NH and NA populations are extremely different in their relationships to the US government, they share the desire to help in educational endeavors as a means of advancing their respective populations' unique predicaments of being indigenous within the US.

NATIVE HAWAIIANS

Native Hawaiians (NHs) are descendants of the first Polynesians to inhabit Hawai'i. After contact by European and American traders, adventurers, missionaries, and settlers, the NH population was decimated by diseases such as measles, tuberculosis, influenza, and others (King and Roth, 2006). In 1893, a coup by American businessmen aided by the US government overthrew the Hawaiian monarchy, imprisoned reigning Queen Lili'uokalani, and "ceded" valuable Hawaiian crown and government lands to the US. While this has been the basis of an ongoing push for restoration of land and political sovereignty, the estates of several land-rich chiefs have supported the wellbeing of the Hawaiian community through Native Hawaiian trusts. A descendant of the Kamehameha lineage, Princess Bernice Pauahi Bishop left her sizeable estate for the education of orphan and indigent Hawaiian children, resulting in the establishment of Kamehameha Schools (KS). The estate supporting the schools (formerly "Bishop Estate") is considered the largest charitable trust in the US, although it had suffered from mismanagement by politically-appointed trustees at the turn of the century (King and Roth, 2006). While NH children are primarily educated in the Hawai'i public school system, they may be able to access K-12 education at KS campuses and college, and they may benefit from KS's public-private partnerships.

The Office of Hawaiian Affairs (OHA) manages a part of the 200,000 acres of "ceded" Hawaiian lands entrusted to OHA when Hawai'i became a state.

The Hawaiian Homelands was established for the purposes of advancing NH well-being and education.

A dispute over the NH sovereignty issue is ongoing, although the US Department of the Interior (USDOI, 2016a) recently approved a procedure by which the NH community could establish a government-to-government relationship. The USDOI (2016b) acknowledges NH culture through the Office of Native Hawaiian Relations, authorized by Congress through public laws in 1995 and 2004. Some NSF programs such as the Tribal Colleges and Universities Program (TCUP) and Pre-Engineering Education Collaborative (PEEC) have provided significant funding to help advance NH STEM students, particularly at community colleges in the University of Hawaiʻi System that represent a greater proportion of Hawaiian students.

NATIVE AMERICANS

Since the first contacts of NAs with would-be traders, colonizers, and missionaries, theirs has been a battle to keep their homelands and their sovereignty. By the 1890s, most tribes in the United States were forcefully relegated to reservations.

Native American is a term used interchangeably by some for American Indian. However, as noted, American Indian and Alaska Native (AIAN), is the official terminology used by the US Federal government. As such, AIANs comprise 567 legally recognized “domestic dependent nations” listed by the Federal government. The AIANs deal directly with the US Department of the Interior (DOI) on a government-to-government basis.

Based upon the trust responsibility stipulated by the BIA between the Federal government and AIANS, education funding is a trust responsibility for reservation residents throughout the United States administered by the Bureau of Indian Education (BIE). A BIA website is available to answer frequently asked questions about the BIA, BIE, and government trust responsibility (BIA, 2016a).

Federal programs have increased base funding for tribally controlled schools from the 1970’s through the 1990’s. Since 2000, NSF’s TCUP and PEEC initiatives have provided funding for the advancement of NA students at tribal colleges. There is, however, widespread disagreement about the adequacy of education funding and the quality of education available for NAs in reservation settings.

South Dakota
Schools in the PEEC alliance in South Dakota include South Dakota State University, and South Dakota School of Mines and Technology as the mainstream schools, working with the lead tribal school Oglala Lakota College (OLC) with its 13 campuses in the western half of the state. Eleven of OLC's campuses are on Pine Ridge Reservation, with one each on the Cheyenne River Reservation and off-reservation in Rapid City.

South Dakota's nine NA tribes are often known to insiders as the *Oceti Sakowin* (Seven Council Fires), or, to outsiders, as the Great Sioux Nation. The Great Sioux Nation has been the subject of many American movies since the advent of films, a source of both accurate and inaccurate information.

Their reservations are spread across the state and some spill over into neighboring states. Their historical homelands covered a vast area in several states, reduced in 1868 by the Laramie Treaty to all of the area west of the Missouri River in South Dakota, and later, through other treaties, reduced to the current nine smaller reservations both east and west of the Missouri River (Jennewein, 1961, pp. 440a-440b). The Great Sioux Nation is best known in history for their resistance to the Federal government. In particular, they are known for the infamous defeat of Lieutenant Colonel George Custer in 1876 at Little Bighorn, and for one of the last major clashes between whites and NAs, the Wounded Knee massacre on Pine Ridge Reservation in the 1890's.

Wisconsin
The University of Wisconsin (UW) at Madison and UW at Platteville are the mainstream institutions working with the lead tribal institution College of Menominee Nation (CMN) in northeastern Wisconsin. However, Wisconsin is the home of other tribes and reservations including Potawatomi, Ho-Chunk (without a defined reservation), Ojibwa, Oneida, Mohicans, and six Chippewa (Wisconsin State Tribal Relations Initiative, 2016b).

During the treaty era, the Menominee occupied a large homeland that was reduced through treaties in the 1800's to the present size of 235,000 acres. Through the Federal Menominee Termination Act, the tribe lost Federal recognition in the 1950's, although it was regained in 1973. The reservation of the Menominee Indian Tribe of Wisconsin is home to some of the most pristine forest in the world with over 90 percent of the reservation in managed forest land (Wisconsin State Tribal Relations Initiative, 2016a).

DISCUSSION AND CONCLUSIONS

Along with recognition of the history of NHs and NAs comes a real sense of indigenous homelands and notions of insiders versus outsiders. Building trust and lasting relationships is critical in this environment. Projects that uplift the quality of life and empower locals are essential, especially in places of extreme poverty in Indian Country (BIA, 2013). Giving priority to “Native voice” needs to be the bedrock of PEEC. Colonized cultures, such as NHs and NAs now served by PEEC, continue to persist through various gradations of resistance and healing. That is why PEEC must take history into consideration in order to achieve positive results under these circumstances. Education is the key to empowering indigenous peoples to train their own, and it can be a powerful tool for tribes in nation-building, self-determination, and in gaining political, social, and economic power.

Generally speaking, the overall American education system is built on middle-class values, and educational success may often hinge on social class and middle-class values more than upon racial issues (Lareau, 2011). Indigenous populations are complicated and do not fall neatly into categories of race, class, or family. Hence, to better understand the complexities that affect them, it is necessary to understand that the collective histories that shape these populations are often vastly different than those in mainstream education, and the motivations that often drive non-indigenous peoples. PEEC is helping to lead the way so that Native voices and cultural values are respected and embedded into education in the best interests of everyone.

Native Hawaiians (NHs) and Native Americans (NAs) possess indigenous cultural identities which are not necessarily congruent with the dominant culture’s understandings of educational attainment and their emphasis upon individuality. The misnomer that NAs and sometimes NHs get things paid for by the government and are “free” is an indicator that the dominant culture does not understand the complicated distinctions that are inherent within indigenous populations. The histories that are often ignored by non-indigenous newcomers to Indian Territory in the adoption of nationalist ideology often involve land rights, treaties, and numerous legalities.

There are many distinctions between NHs and NAs, but both share identities as indigenous. Native Hawaiian students may be eligible for private non-profit scholarship support from Kamehameha Schools and Federal funding for K-12 and some college. Native American K-12 students are also eligible to attend reservation schools that are primarily Federally funded, often based on treaty obligations. Federal funding opportunities for Native students increased from the 1970’s into the 1990’s and resulted in base funding for tribal colleges through a variety of programs. Since the turn-of-the-century, NSF programs such as TCUP and PEEC have advanced STEM education and capacity building at such institutions, discussed in detail in other chapters. Understanding the specific circumstances of all the NHs and NAs is an impossible task, but realizing that their histories matter and that they are indigenous, are critical first steps to successful collaborative projects.

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Kapi'olani Community College 2012 Summer Engineering Experience 1 (SEE 1) students on a huaka'i (excursion) to Hee'ia loko'ia (fishpond) learning about engineering and water flow dynamics. (Photo credit: Aurora Kagawa-Viviani)

3.

Moving beyond cultural sensitivity: Developing culturally responsive programs for and with Native engineers

Aurora Kagawa-Viviani (HI) and Tasha Kawamata Ryan (HI)

INTRODUCTION

Sometimes the discourse on Native students in STEM fields focuses on their absence in degree programs and on a need to increase representation. Public attention shifts to student disadvantages relative to students of other demographic groups. Less attention is directed at creating programs that first acknowledge and then deliberately address the context of intergenerational trauma that many Native peoples have experienced in formal educational institutions.

The Hawai‘i PEEC experience: Indigenous Knowledge in Engineering (‘IKE)

In this chapter, we share our experiences as recruitment and retention specialists from the Hawai‘i PEEC implementation. While we often struggled to reconcile grant goals with our institutions' varying degrees of responsiveness to Native students' needs, we have since learned that this was a common experience across the PEECs. By sharing our stories, we hope to positively contribute to more culturally responsive pre-engineering programs for Native engineers both in Hawai‘i and elsewhere. Our descriptions feature Hawaiian concepts that embody effective practices which may be useful to other Native communities. We connect these to the wealth of insights and experience residing in Hawaiian educational pedagogies and emerging *‘ōiwi* (native) methodologies (Oliveira & Wright, 2015). This section consists of three themes: *huaka‘i* (journey), *kuleana* (responsibility), and *‘ohana* (family), which offer guiding principles for others developing engineering pathways in communities where they do not yet exist.

HUAKA‘I: JOURNEYS OF (RE)CONNECTION

How does one begin to make science and engineering curricula “come alive” for aspiring Native engineers? It begins with the desire to explicitly enable Native students to understand engineering through their own cultures. Barnhardt and Kawagley (2005) remind us that this process is a “two-way interaction.” In such an interaction, non-Native scientists and educators need to recognize and understand multiple worldviews and knowledge systems, while Native peoples may come to understand Western science, but not at the “expense of what they already know and how they have come to know it” (Barnhardt & Kawagley, p. 9). The team of ‘IKE coordinators across the four community colleges (Honolulu, Kapi‘olani, Leeward, and Windward) and the University of Hawai‘i at Mānoa (UH-M) knew that integrating culturally connected concepts would be challenging given that most of the non-Native faculty instructors were accustomed to a decontextualized curriculum. Thus, if culturally relevant integration were to occur, it would be the role of the coordinators to create and implement such activities through a co-curriculum and *huaka‘i* (trip, voyage, journey, procession, or to travel) (Pukui & Elbert, 1986).

In one example, 20 ‘IKE students (pre-engineering and engineering undergraduates) and the coordinators took a three-day camping *huaka‘i* on the island of Moloka‘i. They stayed at Keawanui *loko i‘a*, a restored traditional coastal fishpond, with hosts Hanohano, Maile, and their family. The purpose of the *huaka‘i* was to (re)connect with *‘ōiwi* science and engineering innovations, ancient in origin, but still thriving today, to listen to the stories told by caretakers of various places, and to create reflective moments to strengthen our ‘IKE students’ cultural identities.

Over the course of the *huaka‘i*, the students learned about the ingenuity and dynamics of the Keawanui *loko i‘a*, and they cleaned and opened a part of the *loko i‘a* (fishpond) that had been overgrown. This brief description, however, fails to capture the deep reflective learning that occurred. Such learning was done by *talking story* with Hanohano and his family about their lifeways and values in caring for Keawanui and the community. One community college student reflected:

> *During the Molokai trip, I learned about Indigenous engineers who used natural resources and tools to create intelligent and magnificent projects. The fishpond was one example of Native engineering, which people still utilize . . . . Learning about Native Hawaiian engineering has greatly influenced my degree path . . . . I want to create a device*

> *that would either create solar energy more efficiently or utilize ocean energy.*

Another ʻIKE community college student shared:

> *For me, it was a chance to experience culture face-to-face that cannot be understood except through direct experience. Not only did I gain a deeper appreciation for my heritage, but I also am influenced as an engineer to do what I can to preserve our homeland.*

In addition to making engineering connections, some students also gained affirmations about their own identities as *ʻōiwi* (Native Hawaiian). One community college student shared a reflection linking the concept of knowledge and identity. He stated:

> *Hanohano [our host] mentioned a few times about thinking about the past in terms of the present, and eventually the future . . . . This concept of thinking about knowledge of the past in terms of the present, helps one to find a sense of identity in this modern society that seems so intent on eradicating identity.*

Huakaʻi, therefore, can serve as tools to help students connect to culture and reaffirm their identity. These experiences are often a source of validation for *ʻōiwi* students. They allow students to explore their personal *kuleana* to themselves, their families, and community through engineering and to explore engineering through the lens of "ancient is modern" (Kahakalau, 2002).

The description of the above *huakaʻi* is only partially complete. It is imperative to also recognize the importance of the practitioners who share knowledge during a *huakaʻi*. The expression *he ʻumeke kāʻeo*, which translates to "a well-filled calabash," is befitting for understanding these sources. Although the phrase literally refers to the abundance of food, it is a figurative reference to a person who is full of knowledge. In general, scientific and engineering knowledge and practices are found in every indigenous culture around the world, including Hawaiʻi. However, for students to access, recognize, and understand STEM within Hawaiian traditional practices, collaboration with cultural practitioners is key.

***KULEANA*: FINDING OUR PLACES**

> *The root word of kuleana (responsibility) is kūleʻa or competency. When you have a competency, you have an obligation to use it for the betterment of society.*
>
> -Gregory Chun (2009)

Kuleana (right, privilege, concern, responsibility) (Pukui & Elbert, 1986) is a central concept in Hawaiian thinking. The following describes different *kuleana* of individuals in our Hawaiʻi PEEC. Instructors, while not *ʻōiwi*, provided critical academic training. The coordinator team more closely reflected the ethnic and cultural makeup of the students, and they frequently found themselves providing not just logistical support, but also emotional support and guidance not provided by faculty or administrators.

Noelani Goodyear-Kaʻōpua wrote, “Kanaka [ʻōiwi] have historically been cast as students, not teachers; as informants, not analysts or scientists; as characters in, rather than the authors of, history and literature” (Goodyear-Kaʻōpua, 2015). The coordinators understood this and strove to empower students to influence program design by fostering open communication and encouraging feedback. The internal evaluator coordinated annual focus group meetings at the close of each Summer Engineering Experience (SEE), and created safe space for student peer groups to provide constructive criticism that would be used to direct program evolution. Students understood their *kuleana* to future student cohorts required their thoughtful feedback and that this would improve student experiences in the following years. Students were encouraged to engage their problem-solving and design skills beyond engineering assignments and to apply them for the benefit of the program.

In addition to facilitating a more student-centered program, coordinators saw *kuleana* as encouraging a more culturally relevant learning experience for both students and faculty. They were aware of Hawaiian community members’ and educators’ excitement over culture-based STEM (Chinn, et al., 2011; Furuto, 2014; & Kanahele-Mossman, 2011). We also envisioned *ʻōiwi* engineers engaged in a *pono* (ethical, just) practice of engineering where design and innovation directly benefit their communities; development and engineering have sometimes caused conflict, and parallels might be drawn to the contentious relationship between Hawaiian communities and archaeology (Kawelu, 2015).

The PEEC leaders and students drew inspiration from community-driven efforts to revive traditional voyaging and to restore *loʻi kalo* (taro pondfield), *loko iʻa* (fishpond), and dryland field systems (for examples, see Kelly, 1989). As described earlier, *huakaʻi* and other co-curricular events were the means to help students connect to these and explore their personal *kuleana* to themselves, their families, and community or *lāhui* through engineering. Coordinators learned that helping students explore engineering through *huakaʻi* allowed them to better connect their educational pursuits to their own heritage and genealogies. Exposing students to sources of inspiration and motivation provides spiritual strength to carry them through challenges inevitable in engineering training (Meyer, 2001 and 2003). While this practice has been deployed successfully in Hawaiian culture-based charter schools and a few post-high environmental STEM programs, we are less familiar with its deliberate application in *ʻōiwi* engineering education.

Finally, we identified but were unable to address faculty *kuleana* regarding cultural awareness and attentiveness. Ultimately, we coordinators felt that culturally-attentive and supportive faculty would make the greatest difference in student lives. A goal for future efforts should include increasing faculty awareness of the cultural and historical contexts that shape the students, so that they can better value students' diverse experiences, perspectives, and strengths, and engage in more participatory and place-centered curriculum (Chinn, et al., 2011 & Kahakalau, 2002).

***ʻOHANA*: MODELING SUPPORT SYSTEMS ON FAMILIAR METAPHORS**

Actively engaging *ʻohana* (family) in education has been long established as a best practice (Sing, 1993; & Sing, Hunter, & Meyer, 1999). We had fewer opportunities to engage with student families, so we focus here on *ʻohana* as a model for fostering familiar interpersonal relationships in otherwise culturally foreign academic settings.

Mākua (parent, aunt/uncle) figures have been important to many *ʻōiwi* in STEM fields as mentors whom students trust for calm and wise advice. ʻIKE coordinators and other staff worked to fulfill this role and support emotional needs of students when they were overwhelmed with the rigors of the pre-engineering program or personal matters. Especially effective staff were nurturing and tough-love individuals who gave pep talks or otherwise guided students through difficult times or opaque college processes.

Key familiar relationships of *kaikuaʻana* (elder siblings) and *kaikaina* (younger siblings) were fulfilled through peer-mentoring relationships. We modeled these after and drew student mentors from the strong existing peer-mentoring programs at Kapiʻolani Community College (KCC) STEM and at the 4-year program at University of Hawaiʻi at Mānoa (Native Hawaiian Science and Engineering Mentorship Program). While initially tutoring relationships, these *kaikuaʻana-kaikaina* peer-to-peer relationships are especially important for sharing lessons on course selection and study strategies. Older students served as relatable positive role models just a few steps ahead. Successive student cohorts served as peer support groups, and as each cohort moved forward on their academic *huakaʻi*, they became the *kaikuaʻana* and mentored younger cohorts.

We also connected students to more senior role models from the community of *ʻōiwi* and local engineers at our annual student symposia. At the 2012 inaugural symposium, we asked a panel of professionals to describe their journeys, and they shared their diverse experiences and stories of challenges and successes with younger students and their families as well as staff, faculty, and administrators. It helped all to see that there are different paths to becoming an engineer and for students to relate to those who had made it as engineers.

To describe our community of support, we return to the concept of *huakaʻi*, and to its root, *kaʻi*, (“to lead, direct, lift up and carry, to walk in a procession, to pull”) (Pukui & Elbert, 1986). Many of our efforts attempted to connect students to *alakaʻi* (those who lead or show the way; *ala* = path). We found ourselves fostering a procession, a network of role models, peers, and cheerleaders, to support Native engineers from high school through matriculation and beyond. Later, we conceptualized an ʻIKE model based not on a unidirectional “STEM pipeline” but rather a continuum of student cohorts and community members feeding into a growing and evolving intergenerational community of support. When students engaged in the *huakaʻi*, they connected to people and stories to guide them along the continuum. They gained the perspective that *ʻōiwi* engineers innovated long before engineering emerged as a modern profession and saw that they might simply be continuing an engineering tradition.

We close with three suggestions for pre-engineering programs for Native engineers: *huakaʻi*: move student learning beyond classroom walls, *kuleana*: engage in reflexive practice to find and fulfill individual responsibilities to facilitate Native student success, and *ʻohana*: cultivate systems of support attentive to *ʻōiwi* student needs and community aspirations. Thus, we endeavor to move educational institutions beyond cultural sensitivity toward cultural responsiveness to ensure *ʻōiwi* student success.

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Osceola Blue Horse and Willis Zephier, PEEC interns from Oglala Lakota College (OLC), along with Peter Delgado, PEEC intern from SDSU, summer 2013 on Pine Ridge Reservation, South Dakota. They helped with an OLC project tracking rare ornate green turtles to encourage their conservation. (Photo credit: Joanita Kant)

4.

Invoking cultural relevance at tribal colleges: Grandmother's way is important

Carol Davis (ND), G. Padmanabhan (ND), Joanita Kant (SD), and Richard Meyers (SD)

INTRODUCTION

Nearly all leaders for the Native American (NA) PEECs recognized the desirability of including cultural sensitivity and cultural relevance within their programs. They knew that ties to beloved old-time ways and Native voice could create more interest and persistence for NA students facing rigorous STEM studies. However, some PEECs were farther along that pathway than others. In the case of some, their primary present focus is infrastructure and capacity building. For other PEECs, in places where more capacity building already existed, they stepped up efforts to include Native culture and ways of knowing into their PEEC models. For example, College of Menominee Nation in the Wisconsin PEEC was most heavily involved with infrastructure building, although they recognized that NA cultural relevance mattered. For the Hawai‘i, North Dakota (ND), and South Dakota (SD) PEECs, who were farther along in capacity building, they increased their focus on incorporating Native voice and cultural relevance into their programs.

CONNECTING TO CULTURAL RELEVANCE AND TRADITIONAL WAYS

North Dakota

The North Dakota (ND) PEEC leaders shared their stories of incorporating culture into STEM curriculum through collaborative teaching units. At the heart of their programs is recognition of Native American (NA) science, sometimes referred to as NA ways of knowing. This consists of teachings that have been handed down for centuries to the present generation. Native American science deals in systems of relationships and their application to the life of the community. In ceremony, the participants become one with the universe where all living creatures and living matter are acknowledged.

Within tribes, there is a strong kinship with animals and animal spirits as well as all living organisms, including elements such as water. Many tribal creation stories give direction to the people to acknowledge life within each element. For example, at Turtle Mountain in ND, the tribe's creation story explains that Kitchimanitou breathed life into all plants, animals, and water, giving each a spirit. This differs from Western science where such a belief is generally absent.

The collaboration among the tribal college and mainstream university faculty that resulted from the NATURE program, funded by NSF-EPSCoR (Experimental Program to Stimulate Competitive Research) (Davis & Padmanabhan, 2008) and created in the 1990's, is important to share because it provided the platform for the subsequent launching of the PEEC program. At the heart of that STEM-enhancing program was the recognition that culture and knowledge are connected to all aspects of life (Davis & Padmanabhan, 2008).

Many PEEC students participated in NATURE Summer Camps and Sunday Academies during high school. Of note, Cankdeska Cikana Community College has assisted their "first" tribal member to ever receive an engineering degree. That young man participated for four years in the high school NATURE program and continued into the PEEC program. Each year, several students receive engineering degrees and go to work on and off of the reservations where they are having a definite impact on development of the reservation infrastructure.

For ND, the composition of the instructional team, their cross-cultural collaboration, and the continuity of the team's relationships with students were key elements contributing to student success. At the high school level, NATURE students had STEM teachers who guided their participation. At the tribal college level, students were familiar with the tribal college setting and the STEM faculty because of their previous participation in NATURE. The same was true at the university level, where transferring students knew professors from their participation in NATURE/PEEC. This resulted in students having advocates among the university faculty. Also, because of the two-week Summer Camps at the North Dakota State University campus, Native students were already familiar with peers from the other tribal colleges. Such familiarity helped students to adjust and to experience success.

From the beginning, NATURE classrooms used the constructivist learning method where the STEM lesson began by using the students' prior knowledge to build a lesson. In the North Dakota model, a tribal spiritual/culture teacher introduced lessons from a Native perspective. As the tribal college and university teaching faculty developed courses, they followed a deliberate process to incorporate tribal knowledge.

The process of integrating culture into learning began, once the learning objectives of the STEM teaching units were decided. The spiritual and cultural teachers took the units and developed a tribal teaching that fit the topic. The following are examples of how a lesson on electricity was introduced to students by cultural teachers at each site. At Cankdeska Cikana Community College, Lorraine Grey Bear focused on the Great Thunderbird that is powerful in Dakota teachings. “When the Wakiyan flapped his wings, it became thunder and when he blinked his eyes, it became lightening . . . .” She then explained the power of the Thunderbird by using tribal stories. At Sitting Bull College, Joe Two Bear addressed the laws of electricity by drawing a parallel to Lakota laws governing rites surrounding ceremonies such as the sweat lodge, sun dance, sacred bull, and others. At Neuta Hidatsa Sahnish College, Alice Spotted Bear began the class by telling the Mandan story about Packs Antelope, who gave the people the gift of protection from lightening that resulted in the Low Cap Clan. At Turtle Mountain Community College, Frances Allard-Abbott told the story about Grandfather Thunder and why the people offer tobacco when they hear thunder. Since United Tribes Technical College is not on a reservation but enrolls students from each of the ND reservations, Terry McLaughlin presented lessons from the ND tribes.

Having the culture teacher introduce the lesson using cultural knowledge helped students to identify with the topic. After the cultural introduction, university/tribal college STEM faculty expanded the lesson by utilizing another constructivist concept of building active techniques (e.g., experiments, real-world problem solving) to create more knowledge on the given topic. Instructors then had the students reflect on the lesson, present results from learning activities, and discuss what they learned, demonstrating how their understanding of the lesson changed (Padmanabhan, et al., 2006).

The initial NATURE collaboration consisted of ND’s five tribal colleges and two research universities. The NATURE model included Sunday Academies (Padmanabhan, et al., 2006) and summer programs for high school students at the five ND tribal colleges and programs for tribal college students at the collaborating universities (Lin, et al., 2007). The instructional team at each tribal college consisted of a cultural teacher, one or two high school STEM teachers, two tribal college STEM faculty, one or more tribal college STEM students, and one or more university STEM professors. Some university professors drove between 100 to 250 miles to reach the tribal colleges each Sunday.

From the beginning, educators who designed the NATURE program understood the importance of incorporating the culture of the ND tribes into the multitude of science, technology, engineering, and mathematics (STEM) teaching units offered. Science exists in ceremonies, daily life, and teachings held by cultural and spiritual leaders within the tribe. It was a goal of NATURE to have those teachers become a part of the teaching teams in the Sunday Academies, Summer Camps, and eventually, the research. Another goal was to give the university professors an opportunity to learn about the culture so that they would understand the background of the tribal students in their classrooms when they arrived at the university.

A key element of the Sunday Academy and Summer Camp path was the lesson planning that brought together cultural/spiritual teachers, tribal college faculty, tribal high school teachers, and university professors, the latter coming mostly from engineering departments. Together, the instructional team developed lesson plans and hands-on instructional activities that were aligned with State and National Standards in STEM. For example, in 2010-2011, the Sunday Academy lessons developed were 1) Laws of Electricity, 2) Physics and Computers, 3) Shapes of Nature, 4) Muscle Strength, 5) Foods, 6) Water, and 7) Measuring pH. Once the tribal college and university instructional team completed the lesson plans for the Sunday Academy and Summer Camp instructional units, they gave them to the cultural teachers from the five tribal colleges, and they then wrote appropriate cultural lessons to accompany each topic. The lesson planning and activities provided plenty of opportunities for the tribal college and university faculty to interact and to better understand each other's perspectives, including issues of cultural sensitivity. This increased understanding and helped to ease the Native student transition into mainstream universities, where the ND PEEC has shown unprecedented success.

South Dakota

The South Dakota (SD) PEEC leaders reported that culturally-relevant activities with experiential learning increased interest, persistence, and success in pre-engineering. Not only was such subject matter often of more interest to students, but its importance was often reinforced by family members, tribal Elders, and the general community because of their interest in preserving traditional ways.

Language and culture are inextricably intertwined for many indigenous peoples, and such was the case for NAs participating in SD PEEC. Fitting the term “engineering” into any traditional language is an arduous task. Yet even more essential to cross-cultural projects like PEEC initiatives, is to understand the critical importance of incorporating Native voice. South Dakota PEEC leaders noted that the cultural perspective and vantage point of people who live in reservation communities must be a part of research and program construction.

Other projects also reflected the importance of cultural relevancy in creating NA student interest and persistence. For example, SDSU PEEC summer camp assistant Joanita Kant, at the time an SDSU Biological Sciences PhD student, lived with and mentored SD PEEC interns as they researched heavy metals (As, Ba, Pb, Se, and U) concentrations in water, soil, and plants traditionally used by the Lakota. This topic was of interest to the Pine Ridge Reservation community because of local concerns about uranium extraction activities in neighboring areas. During the research, Kant and the students particularly identified strong community interest in the traditional fruits aspect of the research. Buffaloberry, buffalo currant, chokecherries, wild grapes, plums, and wild roses were and are important in cultural identity and cultural survival among the Lakota. Fruits from these plants continue to be used today in traditional foods, beverages, medicines (both physical and spiritual) and tonics, and for craft items and paraphernalia for Lakota religious purposes (Kant, et al. 2015). Community member interviewees from neighboring Rosebud Reservation reported that these plants hold special significance because they represent the ways of their Elders, often referring to grandmothers and mothers. The fruits are used in the modern day at funerals, traditional weddings, powwows, events honoring Elders, and traditional religious ceremonies such as the Sun Dance (Kant 2013). Interviewee Greg Quigley of Rosebud Reservation explained,

> *My grandma, Lucy Bear Shield, and my grandpa, Thomas Red Bird, taught me what to do with traditionally edible fruits. Presently [2013], I am 48 years old. When I was four, they taught me about how healthy these fruits are. They took me along picking berries. They taught me how to process them because they did that. I learned from them about the ways of long ago. When my mom was alive, she taught me and said, ‘Don’t lose those traditions, or you will lose your life.’ I didn’t give them up.* (Kant, 2013, 192)

To improve interest and future recruiting in STEM, the SDSU PEEC, with additional South Dakota Space Grant Consortium (NASA) funding, launched STEaM Girls (Science, Technology, Engineering, art, and Math Girls), a program at Flandreau Indian School (FIS) for high school students. Understanding the interest in preserving traditions, the program emphasized indigenous ways through activities related to traditional plants and practices (e.g., Kant, et al., 2016). PEEC interns, including enrolled tribal members who are students at SDSU, served as mentors and role models. STEaM Girls participants made authentic Lakota/Dakota beadwork and quillwork using traditional materials, prepared voucher specimens for traditional plants, and established an FIS herbarium. They related their activities to NASA's Visible Earth website focusing on plant ground cover from space, and they toured the Earth Resources Observation and Science (EROS) Center near Baltic, South Dakota. The girls also took three bus trips to SDSU to visit STEM facilities on campus, including the Taylor Herbarium and the Jerome J. Lohr College of Engineering. On Earth Day, STEaM Girls planted over 100 traditional Native plants at FIS, with each girl tagging a plant with her name. The plants are linked to the school's herbarium. Results indicated that incorporating traditional activities increased the girls' interest in STEM studies and careers.

A recent PEEC project in South Dakota involved asking Native Americans of prime college age why they do not often pursue engineering and what would be needed to increase interest (Kant, et al., 2015). By giving primacy to subjects who are Natives, results indicated student motivations were shaped by each student's context, and that engineering education is perceived as a privileged pursuit in a setting where economic poverty and survival shape career choices. In this case, students identified ways in which programs could increase interest in engineering, including articulating relevance to tribal matters and culture (Kant, et al., 2015).

South Dakota's PEEC contributors stressed the importance of understanding Native cultural identity and different perspectives of cultural insiders and outsiders. South Dakota's nine tribes are often known to insiders as the *Oceti Sakowin* (Seven Council Fires), or *the Great Sioux Nation* to outsiders. The *Oceti Sakowin* peoples are most commonly known in history for their resistance to the Federal government and settlers and for the infamous defeat of Custer and the Seventh Calvary in 1876. Along with this identity comes a real sense of indigenous homelands and notions of cultural insiders versus outsiders.

Wisconsin

Most of the Wisconsin PEEC work at the College of Menominee Nation (CMN) focused on infrastructure building. In the words of PI Diana Morris, “We began at square one.” The CMN built a physics lab and engineering/physics facility, and they designed a pre-engineering degree program. When they began working with partners in the last year of PEEC I, they conducted projects using a “women-centered” approach that focused on helping the community.

At CMN, PEEC leaders recognized that to be successful, their connection to the community could not seem distant, as is their perceived image of engineering. In one example, faculty member Lisa Bosman worked with six students conducting solar panel research. Together they looked for the best type of solar panel for a northern climate with snow and rain in a dense forest environment. Students understood the global applications of solar panel research, but what mattered most was that there was a local community connection.

Wisconsin’s PEEC leaders also noted that cultural perspective matters. Diana Morris shared an example reflecting student mentors’ recognition of cultural differences as follows. In CMN’s Green Bay robotics mentoring program, student mentors came from both the urban Green Bay CMN campus and the Keshena Reservation campus and included Menominee, Oneida, and non-Native CMN students. Their Green Bay urban grade school mentees included Native American students as well as Hmong, Somali, Hispanic, and African American students. Through the experience, student mentors learned that understanding their student mentees’ cultures helped tremendously in moving the youth forward academically. Morris noted that each student mentor gained a deepened respect for cultural diversity and cultural identity, and a deeper understanding of culture helped everyone move forward.

CONCLUSIONS

Nearly all of the PEECs involving tribal colleges recognized the importance of involving Native voice and cultural relevancy in student recruitment, persistence, and success in bringing engineering to Native Americans. The North Dakota (ND) PEEC focused on producing and delivering collaborative teaching units where they incorporated relevant NA culture, built on the existing foundation of the NATURE program. Since science exists in tribal practices and ceremonies of everyday life, cultural and spiritual teachers were an integral part of their team for the teaching units. Those culturally-relevant teachers partnered with tribal high school teachers; tribal college faculty; and mainstream university faculty, mostly from engineering departments. The ND PEEC has shown unprecedented success in using their PEEC model.

The South Dakota PEEC conducted several research projects that were and are culturally relevant. Some of those included engaging in many experiential learning activities with tribal agencies and community partners; researching concerns about heavy metals concentrations in water, soil, and traditional plants; and meetings and interviews where they sought community opinions about local values and concerns. They included culturally relevant input in their outreach to NA high schools.

The Wisconsin PEEC was most focused on capacity building in creating a foundation for their PEEC model, although they engaged in some “women-focused” projects in the tradition of strong women tribal leaders, locally. They favored projects that had clear community relevancy, and they recognized the importance of understanding the cultural backgrounds of students in their outreach activities.

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Oglala Lakota College (OLC) wind project. South Dakota School of Mines and Technology (SDSMT) faculty, and OLC and SDSMT students identifying meteorological instruments on OLC campus. (Photo credit: Damon Fick)

5.
Discovering what works: STEM pedagogy and curriculum development for Native Americans

Hannan E. LaGarry (SD)

INTRODUCTION

Is there such a thing as a culturally relevant STEM pedagogy for Native American (NA) students? For the author, it is one of the most frequently asked questions by research collaborators, educators, funders, and even faculty colleagues at Oglala Lakota College (OLC) in South Dakota (SD). It is also a difficult question to answer. The goal of this chapter is to relate how the author approached the issue of curriculum for the SD PEEC at OLC's Math, Science, and Technology (MST) Department. The author's views are not consensus opinions within their OLC's Department of MST, and the author does not consider himself as an "expert" in the area of culturally relevant education. There were, however, some things that were observed by the author by virtue of working with PEEC students, who were raised in the culture. The author shares his observations in this chapter.

As faculty were in the process of writing the PEEC proposal, foremost in their minds was the need to build-in sustainability. A major challenge noted was the probability of a low number of students studying pre-engineering. A traditional engineering curriculum is based on gateway classes, bottleneck classes, strict adherence to sharply defined courses of study, or adherence to a single discipline of study. Instead, the OLC MST department envisioned a program where students, at different levels, in different programs, and in different classes, worked together in one or more interest-based groups. The faculty wanted students to have the freedom to move between groups and to be engaged with faculty, students, and research of interest to them. For their part, the faculty assumed that eventually students would find their niche and complete their academic program. If it were to be successful, this guiding philosophy had to be applied equally to all the students within the OLC MST Department, including the Natural Science students.

OLC MST DEPARTMENT CURRICULAR AND CO-CURRICULAR PROGRAMS

The curriculum that was developed for the pre-engineering program followed the realignment of OLC's B.S. degree in Natural Science. The OLC MST Department's curriculum is based on the premise that engagement is a prerequisite for learning and that, as students become increasingly aware of the demands of a STEM career, they can more easily assume the role of an adult learner. That approach is a departure from traditional programs and is partly based on providing a progressive increase in research participation as follows: 1) 100-level classes emphasize basic content knowledge and a survey of their existing research programs; 2) 200-level classes emphasize the scientific method, technical writing, and guided research experiences; 3) 300-level classes emphasize mentor-selected research projects and in-house dissemination; and 4) 400-level classes emphasize self-selected research projects and professional dissemination. At each successive level of the curriculum, students' coursework, by design, increasingly overlaps with and incorporates their individual co-curricular research projects (Figure 1).

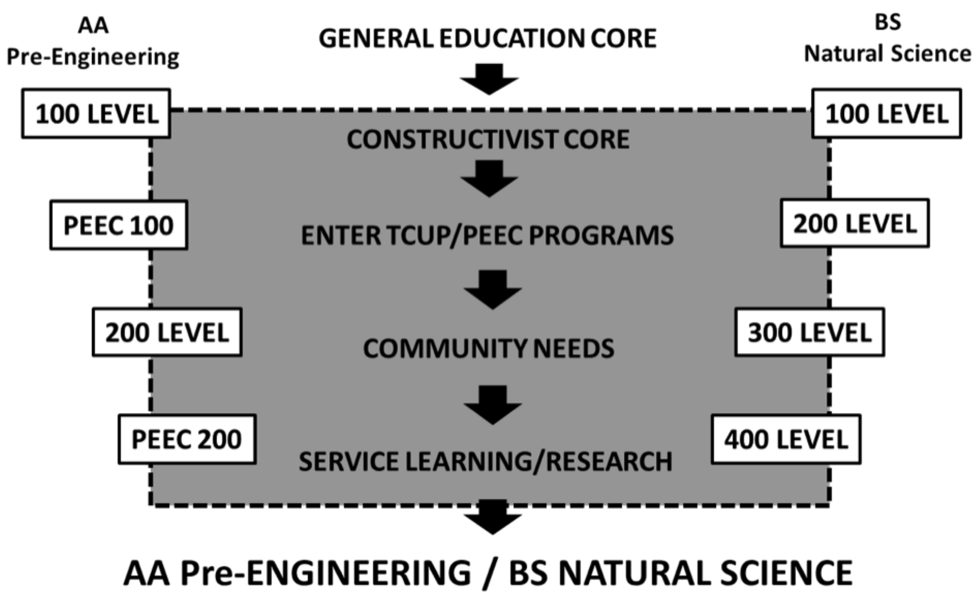

Figure 1. The OLC MST Department's constructivist curriculum (boxes along either side) in relation to its undergraduate co-curricular programs (gray box in center). The degree of overlap between the side boxes, and the central

box, illustrates the degree to which courses at each level overlap with or incorporate students' co-curricular research. (Credit: Hannan LaGarry, Oglala Lakota College)

CONSTRUCTIVISM AT OGLALA LAKOTA COLLEGE

In preparing the PEEC proposal, the OLC MST Department faculty reviewed relevant literature on various teaching philosophies, looking for relevant strategies to employ in working with prospective students who would be studying for a pre-engineering degree. A variety of terms needed to be defined such as "pedagogy" and "andragogy." Pedagogy is how one educates children who are dependent on the teacher and the school to guide and motivate them. Andragogy is how one educates self-motivated adults having their own goals and ambitions (Knowles, 1980 & Lam, 1985). Traditional college-aged students, 18-22 years old, are legally adults, which would suggest andragogy as an educational approach. Typically, OLC students are 90 percent NA, 60 percent female, and 50 percent "non-traditional" (over age 22) with established jobs and families.

For the SD PEEC program, faculty emphasized a curriculum based on undergraduate research and a constructivist andragogy after the manner of Bodner, et al., 2001; Hay & Barab, 2001; Stauffacher, et al., 2006; & Vrasidas, 2000. What is constructivism or constructivist androgogy? The International Encyclopedia of Education defines constructivism as:

> *Constructivism asserts two main principles whose applications have far-reaching consequences for the study of cognitive development and learning as well as for the practice of teaching, psychotherapy, and interpersonal management in general. The two principles are (1) knowledge is mot passively received but actively built up by the experiential world, not the discovery of ontological reality.* (1987)

In their review of the literature, PEEC faculty found constructivism was described as "hands-on" or "experiential" at times. Constructivist practitioners sometimes reported a "flipped classroom" or the "guide on the side," rather than the "sage on the stage," to describe teaching techniques. Constructivism advances an andragogy in which the approaches and outcomes are decided by the learner. Those outcomes are accomplished in a very deliberate and individualized manner, depending upon the learners' goals and ambitions. The student "constructs" their educational experience as wanted or needed, using their individual goals, aptitudes, experiences, and preferences. Based on the review of constructivist literature, combined with established policies and priorities of OLC as a tribal college dedicated to preserving the Lakota language and Oglala culture, the OLC MST Department's pre-engineering curriculum was designed to be place-based and student-directed. It emphasized experiential learning (including a hybridized form of service learning and research), cultural preservation, non-abandonment of students, and co-curricular research.

Place-based

Despite large numbers of OLC students living in Rapid City, South Dakota, off the Pine Ridge Reservation, the emphasis at the OLC MST Department is on the challenges and opportunities available on the Reservation. Such an emphasis on a particular location constitutes a "place-based" philosophy (Williams & Semken, 2011). In addition to keeping OLC students engaged, this approach promotes tribal sovereignty and nation-building, fosters development and utilization of local expertise, and provides OLC students with first-hand experiences working on quality-of-life issues affecting reservation communities. This approach also brings students into contact with tribal agencies and raises local visibility of OLC's MST Department and programs. Many OLC students have a very strong sense of history and place. Few want to leave the region after graduation (Kant, et al., 2015). The place-based approach allows students to take advantage of their long familiarity with the region and allows them to better capitalize on the accumulated recognition they acquire as students in a local college program.

Student-directed

Oglala Lakota College students have the opportunity to develop as professionals and to practice personal sovereignty, independence, self-reliance, and confidence in their sense of ownership of their classroom education, the MST Department, and their research. It also ensures that students decide their overall research priorities and retain their cultural identity, rather than striving to be mirror images of faculty, as discussed by Kimmerer (2002). To facilitate student-directed behavior, OLC has encouraged thoughtful scheduling of classes, faculty mentoring, and skilled negotiating, which allows students the freedom to pursue coursework that complements their research from semester to semester at OLC. The curriculum can be adjusted to fit research directions.

Experiential learning, service learning, and research

Many OLC students are very interested in improving the quality of life of their extended families and reservation communities. Opportunities are many for OLC students to conduct research in service to their communities through PEEC. Therefore, experiential learning (including a hybridized form of service learning) and/or research were integral parts of the SD PEEC initiative. Such projects included, but were not limited to, sustainable food production; renewable energy and energy efficiency; heavy metals concentrations in native plants, water and soil; and various types of design projects involving land and water. PEEC students work side-by-side with B.S. Natural Science students, whose projects often focus on cultural heritage resources, wildlife conservation, and genomics (Sawyer, et al., 2014).

In addition to OLC's STEM curriculum that emphasizes research skills, OLC students are encouraged and supported in the pursuit of both individual and team-oriented research projects such as those described by Berardi, et al. (2003) and Kimmerer (2002). This is supported within OLC's curriculum by a capstone sequence consisting of courses entitled Scientific Literature and Writing, Research Methods, and Research. The capstone sequence, along with a research project, allows OLC students to practice, or "role play" at being a professional engineer or scientist. Within the capstone sequence, students learn proposal writing, literature review, research design, project management, independent investigation, and professional dissemination, among other topics. In terms of assessment, students participate in activities at the mastery level, and OLC uses students' professional dissemination (both poster and platform) as indicators of student success and preparedness for graduate school.

Cultural preservation

Oglala Lakota College MST Department faculty manage the Tribal Colleges and Universities Program (TCUP) and PEEC using a conservationist and preservationist philosophy that reinforces and supports a Native view that the Earth and its living and non-living resources are all interconnected, sacred, and must be protected and nurtured, as noted by White Hat (2000) and Kimmerer (2002). The OLC MST Department students typically cast themselves in the roles of environmental monitors and restorers. Likewise, the students studying Natural Science focus on research that preserves culturally significant species.

Non-abandonment

The OLC's general approach with students is very similar to that of Berardi and others (2003) and maintains a departmental commitment to students that allows them the freedom to try novel approaches or to take risks academically and not lose their internal support. Put another way, a student has a few opportunities to try a research direction, to fail, and then to try again, with little or no penalty. The burden of maintaining such a philosophy falls both on the faculty, who continually write grants to support students financially, but also on the student to stay busy and to be productive despite repeated setbacks. While some students are slow to complete their programs of study, and they may exhaust their financial aid, in most cases enough support can be found to keep a student funded through graduation. Non-abandonment supports a completion-based model in which a higher percentage of a small student population complete the program. This is in contrast to an enrollment-based program which relies on recruiting large numbers of students, hoping that a smaller percentage will be successful and graduate. In support of their completion-based approach, the OLC MST Department has striven to reduce or eliminate bottleneck and gateway courses from their pre-engineering and science curricula.

CONCLUSIONS

The OLC MST Department continues to practice the philosophies and curricula described herein, and continues to attract students to successfully graduate as accomplished professionals, and to expand STEM's reach and influence on the Pine Ridge Reservation. Following the realignment of the OLC MST Department's curriculum in 2008 and 2009, the department raised its retention rate from 20 percent to 60 percent, quadrupled its number of annual graduates (from a low of 2 to 8, on average, with a high of 10 in 2016), and, overall, has placed 96 percent of its students in jobs on the reservation or in graduate school. This success applies to both OLC's PEEC and TCUP supported programs.

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Hawai'i students at the Marine Education Training Center studying vessels, including a double-hulled voyaging canoe. (Photo credit: Hannah Aldridge)

6.

Exploring indigenous science and engineering: Projects with indigenous roots

Alex Parisky (HI), Joseph Ciotti (HI), Jennifer Benning (SD), Joanita Kant (SD), and Floyd McCoy (HI)

INTRODUCTION

The engineering accomplishments achieved by Native Hawaiians (NHs) and Native Americans (NAs) throughout recent history have led to many present-day practices that continue to preserve and promote the legacy of each culture. Native peoples worked within their natural environments and developed innovations that had significant impact on the growth of their societies.

Present day indigenous engineering projects continue to reflect the innovative nature of the ancestors, as modern day Native Hawaiian and tribal serving institutions encourage and support initiatives that promote cultural practices. Cultural continuity for most indigenous communities should begin by recognizing the goals and values of indigenous communities or nations (Champagne, 2006).

For the formation of any complex society, food production is a crucial component. Both NHs and NAs worked within their surroundings to develop and increase food production and live sustainably from the land. In the Kingdom of Hawai‘i, ancient fishponds provide evidence of the NHs' knowledge of aquaculture practices and their desire to promote a sustainable food source. Well before contact was initiated by Europeans, Northern Plains tribes in North America were organized and already subscribing to sustainable food practices (Walde, 2006) through the agricultural proliferation of maize and the mass hunting of bison. These sustainable food practices were developed over hundreds of years and had a significant impact on the development of a complex society.

In addition to food production, many amazing engineering innovations were established over hundreds of years. Both NHs and NAs had developed a variety of solutions for storage of food including pottery, baskets, and food preservation techniques. Both cultures were equally adept at devising methods for increasing food capacity, which included the invention of a variety of modes of transportation that were designed to extend the area in which Native groups could operate.

This chapter will look at some of the engineering feats of NH and NA societies, while sharing some present day projects that have roots in indigenous innovation.

EXPERIENCES OF PEEC PARTICIPANTS BY STATE

Hawai‘i

Two examples of projects with indigenous roots that were important in the Hawai‘i PEEC program included the Hawaiian fishpond and the Polynesian voyaging canoe.

Fishpond

The Hawaiian fishpond was a remarkable feat whereby an ecosystem was designed and managed. There is no similar example of such in the world (Figure 1). Fish traps were common throughout history and prehistory; however, fishponds raised fish from juveniles to dinner fare in a healthy and maintained man-made ecosystem and environment, revealing a native understanding of complex oceanographic, engineering, and biological systems. There is no global equivalent for the Hawaiian fishpond.

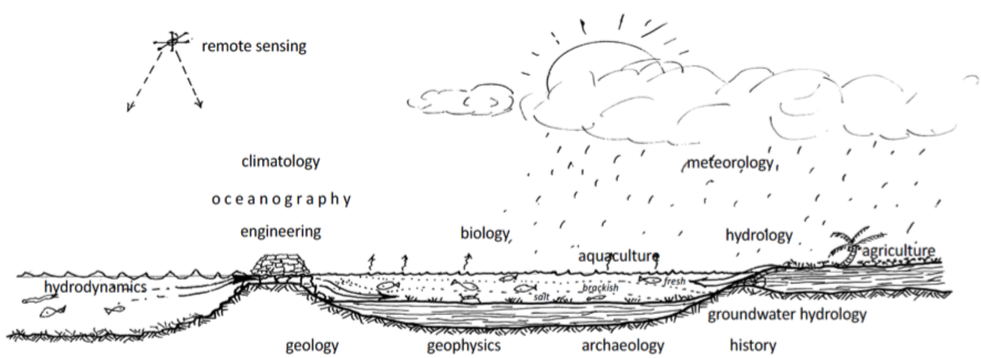

Figure. 1. STEM at a Hawaiian fishpond. (Credit: Floyd McCoy, Windward Community College)

In particular, the *Waikalua Loko* Fishpond, along the shores of Kāneʻohe, is a source of pride for enticing and guiding STEM efforts at Windward Community College (WCC). It is also a natural outdoor laboratory for every aspect of STEM focus, translated into academic courses and studies. Those include bathymetric surveys (to monitor current sediment accumulations and re-dispersal), and mapping using Global Positioning System (GPS) and older technologies (such as traditional surveying techniques). It also serves as an outdoor laboratory for sampling modern sediments (for granulometry, inorganic and organic chemistry, and microbiology), coring for stratigraphic studies (to decipher stratigraphic evidence for natural disasters (e.g., storms and tsunami impacting the fishpond), paleo-climate changes and sea-level oscillations, and benthic and pelagic biological populations through time. Other uses as an outdoor laboratory include archaeological investigations (for understanding alterations to fishpond proposed construction and use through its history), geophysical studies (thus, identifying now-buried, unused gates and fishpond walls), engineering (for understanding ancient rock placement techniques that have withstood numerous storms and tsunami), oceanographic studies on circulation patterns, flushing times, geochemical factors in sediment/water interaction, as well as biological surveys for ecosystem research. A fronting beach has become a laboratory site for determining flux, sources, and types of plastic particles in the adjacent bay.

Voyaging canoe

The latest example, as part of an outdoor laboratory, is the proposed construction of a canoe house (*hale waʻa*) for storing canoes used in the Polynesian Voyaging class, coupled with the complex legal/political procedures needed for such coastal construction. Awareness and pride in the achievements of one's culture, act as powerful driving forces for inspiring students toward challenging endeavors. This empowering motivator has guided Windward Community College's Polynesian Voyaging program since 1996. As the first such curriculum in the University of Hawaiʻi Community College System, this two-semester program with optional sailing labs highlights the engineering feats of the ancient Polynesian explorers by blending traditional voyaging and navigational techniques with modern science and technology.

Students earn physical science credit in team-taught classes that cover topics in astronomy, geology, meteorology, and engineering, as well as Polynesian studies. The first semester focuses on seamanship and the technology involved in voyaging across the vast Pacific Ocean, while the second semester centers on stewardship as applied to the sustainability of these remote islands. Each topic compares and contrasts Polynesian and modern technology, such as wayfinding versus instrument navigation. Pre-engineering and physical science students may take these classes as electives towards their Associate in Science in Natural Science degree.

The incredible engineering feats of the early Polynesian voyagers had long been forgotten and even discounted for centuries until a re-awaking occurred in 1976 with the maiden voyage of *Hōkūle‘a*. Built to the specifications of the ancient long-distance canoes, *Hōkūle‘a* sailed from Hawai‘i to Tahiti, proving that such arduous journeys were possible as deliberate undertakings. In the process, it re-launched the spirit of discovery and elevated the self-esteem of the Hawaiian people. Today, faculty and staff attempt to instill in their pre-engineering students an aspiration to carry on the impressive work of ancestors by reflecting on the wealth of their technological accomplishments. The list is great.

Background of the Polynesian double-hulled voyaging canoe: an engineering marvel

The double-hulled canoe or *wa‘a kaulua*, in Hawaiian, is arguably the most significant engineering contribution of Polynesia. This marvel of technology enabled the epic voyages across the Pacific starting around 1500 BC. By the time western explorers reached Oceania, 3,000 years later, these sophisticated vessels had already made landfall on virtually every island in the Pacific.

The offshoots of nearshore outriggers, these deep sea long-distance voyaging vessels, traditionally consisted of two identical hulls lashed together with crossbeams, deck, and shelter. Their rounded V-shaped hulls were constructed with wooden planks, rather than being dugout, and caulked with coconut fiber and pitch from breadfruit sap (Lewis, 1994). The hull’s compound curves provided superior structural strength while lessening drag.

Unlike monohulls that require a centrally ballasted keel to prevent capsizing, Polynesian canoes exhibited high roll stability due to the wide beam afforded by their twin hulls or outriggers. According to Abramovitch (2005, p. 57), this engineering feat constitutes “quite possibly the first feedback mechanism created by humanity” — predating the water clock by at least 1,200 years.

With a small hydrodynamic footprint, these low-drag ships were exceptionally fast for their period. Powered by one or two oceanic sprit sails made of woven coconut or pandanus leaves (Haddon & Hornell, 1938), these swift vessels were the forerunners of today’s racing catamarans. According to

Captain Cook, who sailed these waters in the late 1700's, at a close-hauled speed of 7 knots, one Tahitian canoe encountered at sea could out sail his HMS Endeavour (Lewis, 1994). As rigged later on Hawaiian canoes, the oceanic sprit sail was modified into curved spars with the aft spar's apex lashed to the mast, giving the sail's leech a concaved shape resembling a crab claw. Calculations by Marchaj (1985) demonstrated that the crab claw sail is superior to today's standard sails like the Marconi/Bermuda at close haul and even better on reaching, delivering some 90 percent more lift.

One drawback of a keel-less sailing vessel is its limitation beating upwind. Tests on replicas like the *Hōkūleʻa* indicate a maximum of 75^{o} close-hauled, "which means the canoe must be sailed over almost 4 miles of ocean for every mile made directly to windward. Thus, a 500-mile trip would require nearly 2,000 miles of actual sailing." (Finney, 1994, p. 127)

The first European sighting of a Polynesian canoe occurred in 1616 when a Dutch vessel encountered a Tongan canoe presumably on its way to Samoa (Howe, 2006). Journals of early western explorers report canoes as long as 120 feet and 33 feet wide carrying as many as 120 passengers. By one account, "a Fijian canoe built in Samoa carried 500 to 600 people" (Haddon & Hornell, 1936, p.43). Recovery of these ancient canoes is problematic. Unlike shipwrecked monohulls that are discovered offshore in shallow water, damaged double-hulled canoes do not have a tendency to sink. They either drift out to sea where they disintegrate over time or are shattered by the pounding surf.

Until recently, the only significant artifacts discovered from an ancient Polynesian voyaging canoe were "an 18-foot long steering sweep and a 17-foot long plank...buried under sand by a tsunami that struck a thousand or so years ago" on Huahine Island near Tahiti (Finney, 1994, p.44). In 2012, a 6-meter section of an ancient Maori canoe, estimated to have been 20 meters long, was discovered on the South Island of New Zealand (Johns, et al., 2014). Made of wood native to that area, this canoe dates back to 1400 AD.

Starting in the 1970's, Hawaiian artist Herb Kane inspired a renaissance in Polynesian voyaging with his masterful canoe paintings, relying in part on the detailed descriptions and illustrations of Polynesian canoes recorded by such explorers as Samwell and Webber, who accompanied Captain Cook on his last voyage to the Pacific (Kane, 1997). Today, a new fleet of Polynesian double-hulled canoes follows proudly in the wake of these ancient Polynesian marvels of engineering.

Relationships of field exercises to laboratory and lecture-based courses on campus have not only led to new courses, but to the insertion of place-based concepts and cultural identity into existing science courses. As examples, the Geology of the Hawaiian Islands course requires not only the usual English scientific terminology, but also its equivalent in Hawaiian. The pride of Hawaiian students that their language can be equally significant in scientific nomenclature is notable. The Geographic Information System (GIS) mapping courses place historic maps and images into temporal sequences to detect fishpond alterations consequent to natural and anthropogenic changes, as well as to utilize new remote-sensing technologies. Oceanography labs focus on physical, chemical, and biological conditions and are stunningly successful, as are labs that focus on archaeology, history, and legend. Outdoor laboratory exercises have enormous input into new computer-assisted mapping programs and visual depiction techniques. Each of these can find improvement in curriculum development, design, engineering, and use – again a challenge for students and a foundation for STEM. As a result, *Waikalua Loko* has also been the focus for numerous scientific research programs from the University of Hawaiʻi (UH) that attract undergraduate students.

South Dakota

The South Dakota PEEC included projects with indigenous roots. One of those was an investigation into the restoration of a memorial wall near Wanblee, South Dakota (SD), on the Pine Ridge Reservation that honors World War I and II veterans. This memorial wall was constructed by John High Horse in 1947 and includes a list of 230 names of Native American veterans carved into sandstone panels that are imbedded into a concrete wall, supported by a concrete foundation. The memorial had been moved from its original site to its current location at Crazy Horse School in Wanblee in the late 1970's, and, over time, the weathering of the sandstone panels made many of the names unreadable, and the concrete wall and foundation were deteriorating (Fick, et al., 2012). Three PEEC students were involved in researching and analyzing potential methods to restore the wall, but after further conversation with the community, they left the wall unrestored. The community felt that the naturally weathered state was culturally relevant and important to them. In the end, PEEC students and faculty gained valuable insight into the importance of respecting culture in their community service projects through this experience (Kant, et al., 2014).

Another South Dakota PEEC project with indigenous roots is an on-going project for the design and research of sustainable food production systems. Lyle Wilson, a construction technologies instructor at Oglala

Lakota College (OLC) and a Lakota community member, approached South Dakota School of Mines and Technology (SDSMT) partners with the idea that students could help design greenhouses. Pine Ridge, like many Native American reservations across the country, is classified by the U.S. Department of Agriculture as a “food desert,” due to both the geographical and economical access to healthy foods. Food sovereignty is a critical cultural right for indigenous people globally as expressed in the Declaration of Atitlan, a Global Consultation about indigenous rights (Indigenous Peoples’ Global Consultation, 2002).

Over the course of three years, this project has involved many SDSMT and OLC students in the design and construction of a hoop house at OLC’s Kyle, SD, campus, as well as the design and installation of instrumentation and renewable energy testing strategies and monitoring equipment (Benning, et al., 2014), and the design of a year-round production geothermal and passive solar greenhouse.

An additional SD PEEC-related project with indigenous roots was partly funded by the South Dakota Space Grant Consortium. Known as “STEaM Girls,” an acronym for Science, Technology, Engineering, art, and Math Girls, results indicated that STEM interest increased for NA high school girls. In the project, three SDSU faculty and staff members were assisted by five NA women students (two graduate and three undergraduate) and community volunteers. They engaged in activities with indigenous roots to increase STEM interest among 30 NA high school girls at Flandreau Indian School (FIS), a Federal boarding school near the Flandreau Santee Sioux Reservation in SD. Overall topics included glass-making manufacturing techniques and native plants. When emphasizing engineering, leaders turned to what used to be known as “domestic engineering” in order to create interest through hands-on learning in a kitchen-like setting. They explored glass manufacturing techniques through You-Tube, analyzed glass beads and historic beadwork designs, and considered glass-like properties in liquid and semi-liquid sugar-based candy. They identified traditionally used native fruits such as chokecherries, collected the wild fruit, made perfume and traditional tribal foods, established a school herbarium, and installed Native plants on the FIS campus. They produced an activities booklet (Kant, et al., 2016) for future use that includes Dakota and Lakota recipes, and instructions for canning and making perfume with native plants. In addition, the booklet includes notations on avoiding the use of certain stems, leaves, pits, seeds, or green fruit when making traditional foods because of the possibility of mild poisoning from cyanogenic glycosides. Pre- and post-surveys, as well as a focus group at project's end, indicated that activities such as these with indigenous roots increased interest in STEM studies and careers.

CONCLUSIONS

Creating and implementing projects with indigenous roots helps to increase interest in STEM and generates cultural pride that may improve student persistence, and it helps in recruitment. PEEC projects rooted in indigeneity increase encouragement from the community, family, and Elders, who help to keep PEEC students moving forward to reach their goals.
The need for NH and NA serving community colleges to preserve and restore traditional practices is necessary to promote STEM student success and to preserve indigenous ways of knowing. Such practices help to perpetuate values and pride among indigenous cultures and to pass their evolving traditions along to future generations of NHs and NAs, while adding to general knowledge.

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Some South Dakota PEEC faculty and students near Slim Butte on Pine Ridge Reservation, studying and geologic mapping in the White Clay Fault near Slim Butte, Southwest Oglala Lakota County, South Dakota. From left, Kristina Proietti (SDSMT student), James Sanovia (faculty member at Oglala Lakota College), Michael Tekkle (SDSMT student) and Foster Sawyer (faculty member at SDSMT). (Photo credit: Tyler Rust)

PART III: Providing support for Natives in Engineering

7.

Finding an Engineering identity: A Native American PEEC leader's experience

James J. Sanovia (SD)

INTRODUCTION

I, the author, am relating my story because it may be helpful for others to know my pathway to eventually establishing my Engineering identity, something that all engineers face (Meyers, et al., 2012). The difference, in my case, is that I am a Native American (NA) with that cultural background. College campuses are their own cultures, and Engineering is its own culture. Reservations have their own cultures, and non-reservations have their own cultures, too. In each instance, there are norms about operating within a "culture." I needed to find a way to walk in all of those cultural worlds in order to realize my aspirations. I started out as a pre-engineering undergraduate student at a tribal college, Oglala Lakota College (OLC), and I became someone who is now on the way to a Master's at a mainstream engineering university, South Dakota School of Mines and Technology (SDSMT) in South Dakota. This is my story.

I came from a very social, musical, and rather uneducated background and I had to learn a new take on life, dealing with privileged, highly intelligent introverts. Learning about introverts and that I, too, was and am an introvert, was a new experience over the years to come. Getting the right support and mentoring led me to be a successful student and now a faculty member.
I am an enrolled member of the Rosebud Sioux Tribe (RST) Rosebud, South

Dakota. I am also Oglala Lakota from the Oglala Sioux Tribe (OST) in Pine Ridge, South Dakota. My mother is a RST member and my father is an OST member; thus, I have equal family from both bands of Lakota.

I need to start by noting that I am not a PEEC student, but rather a PEEC Co-Principal Investigator and faculty member (Geospatial Laboratory manager and researcher) in the Mathematics, Science and Technology (MST) Department at Oglala Lakota College (OLC) in South Dakota with a B.S. in Geological Engineering

Presently, I am the only known Lakota geological engineer from any of the seven bands of the *Lakota Oyate* (Nation). I am also a first generation college graduate within my family. I am approximately one school year away, or 6 class credits and a thesis completion, from finishing my Master's in geological engineering. On the Pine Ridge Reservation there are approximately five known Lakota engineers, and I am one of them. None of us has a Professional Engineer (PE) certification nor a Master's in engineering. I do not know if the other four engineers practice as professional engineers.

This chapter is about my experiences as a pre-engineering student at OLC all the way from starting my undergraduate degree, through my graduate studies and to my current position as an OLC faculty member and PEEC leader.

STARTING OUT (SPRING 1999 – SPRING 2003)

I started fulltime classes at OLC in Spring 1999 but would not be accepted to the OLC Model Institutions for Excellence (MIE) program until approximately Spring 2001. I was originally planning on doing my basics at OLC, and then transferring to SDSMT until I heard of the Model Institute of Excellence (MIE) program. I was immediately interested in their Science Engineering and Mathematics (SEM) pre-engineering program and was mentored by several OLC faculty to take up geological engineering.

During this time it was evident, even more so as I look back, that the OLC MIE Department was significantly funded. This time period signifies to me when the STEM culture atmosphere was created at OLC. The culture was so sophisticated that there was even an engineering club type environment where it was common to see groups of engineering students bundled together studying or talking about the best mechanical pencil or graphing calculator. There were other STEM club type groups as well, although I do not know as much about them, since I was fully immersed in the engineering disciplines.

Sometime about the 2001-2002 school year, STEM projects or the first stages of departmental faculty-student research became evident within the OLC MIE Department. There were so many MIE students at that time that we had to apply to an OLC MIE faculty researcher in order to be accepted to work with them. There were also many OLC MIE faculty, and it was difficult looking back and seeing who only taught, who did research, or who did both.

At the time, SDSMT kept their presence noticed by attending several monthly mandatory OLC MIE meetings throughout the school year. Recruiting was their main initiative with some SDSMT faculty offering research support. The participation of the Office of Multicultural Affairs (OMA) at SDSMT played a role in keeping a small line of students matriculating from OLC to SDSMT. This great relationship mainly existed because of the extra efforts of OMA director, Jacquelyn Bolman (a Lakota PhD) and her assistant, Julie Wells. When they permanently left the OMA office (2003) this relationship almost disappeared over night. These two individuals were the only support for NA students during this time.

As OLC MIE students, we were allowed to take some classes at SDSMT. Being able to take one or two per semester at SDSMT helped greatly with integration but not entirely. At that time there was only the American Indian Science and Engineering Society (AISES) chapter at SDSMT and no other Native support groups, very little mentoring or much of anything related. Therefore, taking a few classes at SDSMT before fully enrolling there helped prepare for the inevitable cultural and academic shock. The rigorous workloads and homework deadlines at SDSMT also helped the students' remaining classes at OLC to be even more punctual.

TRANSFERRING FROM OLC TO SDSMT (FALL 2003 TO SPRING 2008)

Transferring from OLC to SDSMT was no easy task, since there was no mechanism to make this process less confusing and painful. However, during my last year at OLC, the OLC MIE Department helped me to apply for major scholarships. I was awarded a David and Lucile Packard Foundation four-year scholarship worth $5000 per semester. This was of great help, since I was approaching using up all of my financial aid. It took me four years to get a two-year degree at OLC, mainly because I started college with seventh grade mathematics.

From 2003 to approximately 2007, I worked part time as an intern/mentor with the OLC MIE Department, and eventually it was renamed the Math, Science and Technology (MST) Department. Around 2003 or 2004, the OLC MST Department built a building for the department. I, along with a few other OLC MST Department interns, helped with the construction of the building, since research/projects were basically on hold until the completion of the office and laboratory areas. Once the building was complete, there were only a couple interns at the OLC MST Department, including me, even though I was studying at SDSMT.

The time between 2003 and 2006, while working on my undergrad degree at SDSMT, I mentored OLC students with geospatial related projects. Near the end of 2006, the department's environment changed. There were fewer student interns, and the STEM culture that the MIE grant helped create was starting to fade.

While at SDSMT, I spent my undergraduate career without much intervention from anyone other than my departmental professors and Jacquelyn Bolman, who was now working at the South Dakota Space Grant Consortium at SDSMT. As mentioned before, there were no programs for Native groups since the OMA office was going through high turnover rates with directors ever since Bolman left the position.

Summing up, 2003 to 2008 represents the time during which I earned my B. S. geological engineering degree at SDSMT. Thus, including my time at OLC, it took me about eight years to get my undergraduate degree! This was one of the most difficult times in my life. Luckily my partner Lilly, our kids and my family in general, were always supportive of my going to college. While at OLC, I was always treated with respect and encouragement. It also is important that I acknowledge the MIE project that financially helped students, including me. Transferring to SDSMT was as difficult as it got, but with perseverance and great faculty at OLC and in the Geology and Geological Engineering Department at SDSMT, I made it through my academic endeavors.

OBSERVATIONS FROM BEING A NATIVE STUDENT AT A MOSTLY WHITE INSTITUTION

Few know that while I was a Native student at SDSMT, my time there was not made easy by fellow undergraduates. After Bolman left the OMA office, and SDSMT for that matter, I, in some minor ways, became the campus' unrecognized and improvised school counselor for NA students. Those students constantly approached me with racial issues from other students in their classrooms and also asking where to get academic help. I, myself, dealt with several racial issues while going to school there. All of us were used to such a lifestyle, typical in South Dakota life for NAs. In each case, if the issues were not severe, we just brushed them aside.

The reader may wonder “Why would you not say anything?” We all thought this through and came up with two reasons as to why we did not pursue these issues during this time. First, SDSMT basically appeared to the Native American students as having an all-white staff with mostly ”locals” filling those positions. Thus, this was not a comfortable position for a Native American student to want to bring up such an issue, unless it was severe. I guess we worried about retaliation from school staff/faculty or even the students, if we brought up such issues. Second, and ultimately, the consensus was all of the *time* such a process might take by following through and dealing with it. Confronting a racist student might label the Native American student as a trouble maker, as well, making it difficult to connect with other students for study groups. Keeping in mind that if one is a minority student in an undergraduate engineering class, one may be the only minority in a class with all white men and perhaps one white female. It was important for all of the students to be invited or accepted to a study group. That was considered somewhat of an honor/achievement, at least for a few of us Native American students.

ADVICE TO NATIVE AMERICAN ENGINEERING STUDENTS

After experiencing some time as a Native American college student at OLC and my first year at SDSMT, I generated some questions that I might casually ask my white undergraduate college peers from time to time. This was done because I was curious, and I knew that my Native American college friends were, too. Also, most Native American students are first generation college students, and they did not grow up in an environment where such topics were discussed or even mentioned. The questions and the answers are as follows.

- When do you study and for how long?

  For most students, they studied all day when not in class and some nights in study groups. Sometimes one laboratory report for one class could take about twenty hours to finish within the week. That was even with a legacy file, information from students who had taken the course previously.

- Where do you do your homework?
  Some students mentioned that they do so in their dorms or at the school library; juniors and seniors reported doing homework within their own department building or the library at night.
- What does your homework look like?
  Homework was mostly very neat, orderly, and correctly formatted on engineering paper.
- Do you study with others?
  Study habits were mentioned and the expectation was that they study alone.
- Do you do homework with others?
  The majority of responses reported, yes, most of the time. In my personal experience, four out of five group homework partners were usually well-read and had some of the laboratory/homework already started or even half of it finished.
- Do you study on weekends?
  Several students said that no homework was done on Fridays or Saturdays.

COPING STRATEGIES I DEVELOPED

I always made sure everyone in class saw my laboratory scores, and I made sure they were in the +90% range, at least most of the time. I think this method worked, and it helped me to get invited to evening homework/study groups. Some students just flat out asked how each of us did on a laboratory assignments or exams. During that time and to the present day, I would share all of the results that I had.

During my time at SDSMT, I stayed in close touch with OLC faculty by continuing my internship with OLC. The OLC offered undergraduate research/projects and by this time I had been trained on various instruments and field equipment. I trained other OLC students based on what I learned. In order to fine tune my research or to take it to the next level, I worked with SDSMT faculty. Those were ways that I weaned myself from OLC, but only for a couple of years.

In reflecting on my time at SDSMT, through my undergraduate experiences, three long lasting experiences remain with me to this day. First, it is important to speak up while going to school there. Most professors are not going to approach you and ask about your day, your family, and how school work is going or even if you need any help with something. The SDSMT is not a tribal college where professors hand out their personal cell phone number, as they do at OLC. I remember that once I crossed that threshold of starting to speak up, I was forever thankful for having done so. Knocking on a professor's door or stopping them in the hallway might be a nerve-racking thing to do for most NA students that I encountered, but it is not for all of them. That is also the case for NAs in approaching SDSMT tutors.

The second issue was recognizing how to work with tutors. The SDSMT tutors were available six to seven days a week during most times. The problem was a student's willingness to visit them if help were needed. I heard a lot a negative stories about the "Tech" tutors in the library basement. Most, but not all, stories were true, but I think it depended on from the angle from which one perceived the stories. The perception of the tutors, by other students with whom I associated was that they were mean, scary, intimidating, and possibly racist. Stepping through my fears, based mainly on my having to deal with white people - especially white SDSMT undergraduates - I was able to start working with the SDSMT tutors. I would eventually visit them often for homework help in various classes.

The third issue was realizing that not all that I heard was true. After getting used to coming there for tutoring, I witnessed why they had such a bad reputation. This was caused by students who came in to get help, but they had not even started their homework. The students wanted or demanded that the tutors help them all of the way through it. I noticed that if I had made some sort of effort and knew some of the material, the tutors were always happy to help, regardless of the color of my skin. These tutors were probably the top of their classes, and some were even graduate students. They were not there for amusement; they simply wanted to solve problems but only if the student needing help was serious about solving problems. Thus, I got comfortable enough working with them and with other students after I had some side lessons with my homework and with college time management. Walking to the tutor's room, I needed to walk through many areas where there were groups doing homework together. This was also a good learning experience for me in witnessing this new phenomenon.

The last two topics raised the issue of *perception*, through the eyes of a Native American engineering student looking at an engineering schools' environment and its people and where I could fit in.

At the end of my undergraduate time there, I actually became friends with several new people or at least was able to work with them. They were mainly white people. I did my best to search for positive students with whom to work and be around, and I avoided those who were negative or outright uncaring. I would eventually experience that the majority were good people, even if we rarely communicated.

RETURN TO OLC Fall 2011

During the Fall 2010 semester, I was hired as an adjunct faculty member to teach Geographical Information Systems II or Applications of GIS, which was part two of three in the geospatial curriculum with the OLC MST Department.

In January 2011, I was hired fulltime as the GIS Laboratory Manager/ Technician. I was to re-start the OLC MST GIS laboratory and to make something useful of it. At the time, the MST Department appeared to have rebounded with a great number of science and pre-engineering students. Monthly meeting attendance was around 20 MST Department student and faculty members.

CONCLUSIONS

I established my Engineering identity by learning to walk in a variety of cultures and to navigate their customs and rules of operation. Those cultures included Native American, reservation, non-reservation, college campus, Engineering, and many that I probably do not recognize as such.

My recommendations for a successful undergraduate experience are to focus on homework, especially laboratory homework, and make friends so that the student can at least get into a study group or find a study partner. Make sure that your life is adjusted for the rigorous homework that you will encounter. The homework will be long and difficult, but feasible, with unforgiving due dates. It is all about keeping up and handing in good work in a short amount of time and on time.

I graduated with a B.S. in Geological Engineering along with two other Lakota with different degrees in Spring 2008. I was the first and only one in my family to finish college with a B.S. degree. This was only achieved through hard work and the everlasting support from my wife Lilly, our three kids, my parents and brothers, and the rest of my *tiospaye* (family, extended family, and my community).

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Humanities and American Indian culture met engineering and other STEM fields when College of Menominee Nation (CMN) students produced and published series of books for young readers. Written and illustrated by CMN students, the stories told about fictional Native children learning how engineering know-how solves everyday problems. Faculty member Ryan Winn of CMN's Theater program advised on the project and took part in a public debut of the book. Copies of the two, five-book sets have been donated to schools throughout the College's service region. (Photo credit: CMN by DKakkak)

8.
Outreaching to K-12 and tribal schools in PEEC

Robert Pieri (ND), Hannah Aldridge (HI), Misty Brave (SD), Hannan LaGarry (SD), G. Padmanabhan (ND), and Lane Azure (ND)

INTRODUCTION

In general, college administrators grapple with the question of how K-12 outreach activities relate to pre-engineering and science degree programs, largely because of the difficulty of directly linking the outreach activity to the purposes for which students ultimately enroll in college and graduate. Correspondingly it is difficult for PEEC grant PIs to answer the questions of how K-12 outreach directly impacts Native Hawaiian (NH) or Native American (NA) student engineering graduation rates and how they can justify the use of costly resources. These are fair questions, explored as follows.

Research has shown that such K-12 and tribal school outreach is crucial to the creation of smooth pathways for NA and NH students to pursue engineering degrees. Many researchers recommend that engineering concepts be embedded in the K-12 curricula (Bybee, 2011; Moore et al., 2014; National Academy of Engineering, 2010, Chapter 1). Even if not directly embedded, those concepts could be brought to bear on students via summer camps and evening and/or weekend STEM enhancement programs. In order to be effective at kindling the fire of “engineering thinking” in students, these activities need to be designed and delivered collaboratively by tribal college and university engineering faculty, who clearly understand what engineering is and what it is not. Most engineers understand “ST_M” but most scientists, mathematicians and programmers are not familiar with the practice of “__E_”. Currently, many outreach activities broadly target STEM as a way of drawing students to engineering because it allows a wider array of topics and projects to gain initial student interest.

Outreach can also be a tremendously diverse activity in multiple contexts. In North Dakota and South Dakota it can mean hundreds of miles between schools, while in Hawaiʻi it may involve trying to connect eight public high schools, one charter school, and one private school, as well as a number of community events, on just one island! The aim was to visit public high schools in areas with a high populace of NHs. *Haumāna* (students) from the Leeward coast of Oʻahu as the primary recipients of most efforts.

The following are more detailed examples of K-12 STEM outreach activities to K-12 and/or tribal schools in Hawaiʻi, North Dakota, South Dakota, and Wisconsin.

HAWAIʻI

In Hawaiʻi, PEEC outreach included visits to public high schools in areas with a high numbers of NHs. A goal was to place newly graduated high school seniors in mathematics and science classes into the summer bridge program, Indigenous Knowledge in Engineering (ʻIKE). In addition to high school visits, PEEC represented manned tables at several NH community events, presented at state science fairs, attended high school robotics teams, and visited any willing school and grade level *Haumāna* (students) from the Leeward coast of Oʻahu.

What worked in PEEC recruitment and outreach in Hawaiʻi

In the Hawaiʻi PEEC within the classroom, the most effective method of delivery was an interactive PowerPoint, accompanied by a team of energized PEEC representatives. Working in teams was extremely beneficial in keeping high energy in the high school classroom. The opening slides of the PowerPoint explained why students may not be interested in STEM. PEEC participants shared personal stories about how immediate *ʻohana* (family) are rarely in the STEM fields, and, as Hawaiians, they may not want to pursue an unfamiliar field. Presenters showed photos of *kūpuna* (ancestors) engaging in activities familiar to NH students such as navigation and farming. Presenters explained that those examples constituted the essence of science, although not as easily identifiable in today's society. During this portion of the presentation, students would often adjust their seating and posture, pulling their shoulders back, envoking a stance of pride. It is important for students to know that their *kupuna* (ancestors) have always been scientists. After the presentations, oftentimes, over half of the class signed the contact list for the upcoming summer bridge program.

Outside the classroom, word of mouth was and is the greatest recruitment tool. The PEEC program representatives have never visited a high school where a majority of their graduates attended the PEEC program without some recruitment efforts. Personal recruitment from past PEEC participants proved to be the richest technique.

A basic challenge in outreach was navigating the unique culture of each K-12 school. Each school had a different process for presenting in a given classroom. Depending on the school, the first point of contact could be a college counselor, while other schools required approval from the principal. At times, the red tape surrounding access to the classroom prevented PEEC recruiters from reaching an intended target school.

For future outreach, creating strong relationships and becoming highly visible in the schools is pertinent. The Hawaiʻi PEEC established strong follow-up through e-mail and telephone contacts collected at recruitment events. Such efforts facilitated the receipt of students' summer bridge applications in a timely manner.

In conclusion, the following is an experience that summarizes a lesson from PEEC outreach efforts. One of the Hawaiʻi PEEC associates received a *makana* (gift) from a colleague. It was a potted *kalo* (taro) plant. Traditionally, there is a significant responsibility in accepting such a gift, since *kalo* is a representation of *Hāloa*, the original ancestor of Hawaiian people. The *kalo* started with just two *hā* (petiole or stems) and *lau* (leaves), and it maintained its short height, without bearing any *keiki* or *ʻohā* (offspring or offshoot). Although watered daily, with *aloha* (in this case, meaning "with love and affection") for five months, only two *hā* remained. Might the *kalo* be "beyond my watering"? Perhaps it would never grow; after all, the *kalo*'s natural habitat should be in a *loʻi* (taro patch) with continuous water streaming through, and not in a pot in a concrete jungle in the back yard, watered by a hose. At month six, out of a sense of impatience and extreme determination for this *kalo* to produce *ʻohā,* the owner added more soil and doubled the water supply.

As it turned out, persistence was the key. At month seven, two *keiki* begain to sprout. With great excitement, a community of supporters helped to maintain the daily watering, and, eventually, three and four more *hā* sprouted. The next week there were five and six *hā*. The following week, seven, then eight *hā* appeared. As of this writing, there are five *keiki* and 26 *hā*! This story is pertinent because it illustrates that the NH *haumāna* need persistent watering, attention, and support in order to thrive. The PEEC students are learning in ways outside their natural and innate learning environment, and the PEEC program must persist in nurturing them. With time and consistency, the PEEC and PEEC-related programs will be fruitful.

NORTH DAKOTA

As stated elsewhere, the key to building effective collaborations is long-term mutual experience and respect among the partners. In North Dakota that started in approximately 1997-1998, when a group of tribal college presidents collaborated with engineering, mathematics, and science professors at North Dakota State University (NDSU) to put together what would be called “Project Navy,” because of its sponsorship by the Office of Naval Research (ONR). As illustrated in the Figure 1, the approach was to recognize three distinct populations of students and to try to encourage their contributions to the community. The program eventually partnered with NDSU and the five North Dakota tribal colleges (Cankdeska Cikana Community College, Fort Berthold Community College [renamed Nueta Hidatsa Sahnish College], Sitting Bull College, Turtle Mountain Community College, and United Tribes Technical College).

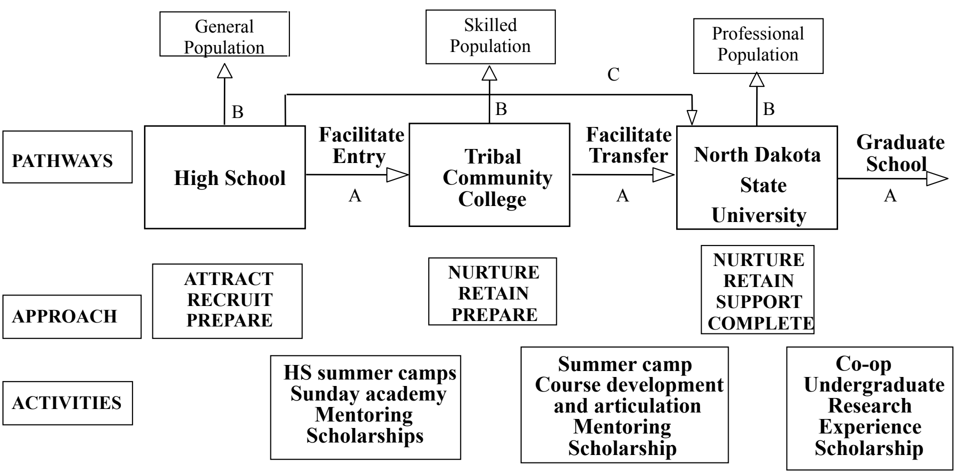

Figure 1. Native American student pathways in the Office of Naval Research project model. (Credit: ND PEEC)

This approach has been validated through research by scholars such as Cleary & Peacock (1997), Dean (2004), & Barnhardt & Angayugaq (2005), who revealed that careful documentation of key cultural indigenous knowledge related to science and math, through consultation with tribal teachers, can lead to common ground with Western scientific processes. Results indicated that student engagement in a dynamic learning activity brings forth scientific knowledge that also extends cultural awareness for students, thus, meeting academic standards in the process.

The initial effort has gone through several iterations and is currently titled Nurturing American Tribal Undergraduate Research and Education (NATURE). It is currently funded through North Dakota Experimental Program to Stimulate Competitive Research (EPSCoR) with a slight shift in outcomes, although the program still connects tribal students with hands-on experiences in STEM areas through Sunday Academies and Summer Camps both at mainstream institutions and tribal colleges.

It is the extension of this NATURE program that forms the basis of current outreach efforts to K-12 and tribal schools, as modified by the local presence of PEEC instructors at the tribal colleges. In order not to confuse recruitment to NDSU with involvement in the PEEC program, it has been the emphasis of North Dakota PEEC leadership to allow the tribal institutions to lead in that outreach to local schools. The NDSU has offered help to support those efforts, to include student engineering groups and alumni from the local school systems. Several efforts have been made to travel to area high schools by PEEC students from both local tribal colleges and NDSU, to give presentations during assemblies or lunches. Tribal high school visits to NDSU have also been supported through tours, luncheons, and visits with the on-campus PEEC cohort (usually connecting friends or relatives).

However, the most effective outreach is probably for the local tribal PEEC instructors to connect one-on-one with local K-12 STEM instructors to identify students who might benefit from participation in the PEEC program. This becomes a bit of a problem because of the rapid turnover of STEM instructors in local tribal school districts and specific rules within different school districts. The rapid turnover of STEM instructors may actually present an opportunity, since some tribal college PEEC engineering instructors have offered some of the local districts demonstration opportunities in science and mathematics classes. This has extended to offering summer pre-engineering camps and engineering competitions (e.g., “Who’s faster: the human or the machine?”) that have been covered by local television stations.

SOUTH DAKOTA

Outreach at Oglala Lakota College (OLC) is largely supported by grants to OLC’s Mathematics Science and Technology (MST) Department from the following: NSF TCUP III (National Science Foundation Tribal Colleges and Universities Program III (NSF TCUP III), South Dakota EPSCoR, National Aeronautics and Space Administration Science and Engineering Mathematics and Aerospace Academy (NASA SEMAA), Honda Foundation, and Colorado State University. Brief descriptions of these programs follow.

NSF TCUP III "Yuowanca" Teacher Training Institute
In addition to building capacity at OLC, this grant included a K-12 teacher-training program designed to support and prepare science and non-science teachers in the summer, with activities during the school year. Through it, reservation teachers are encouraged to be a part of OLC's MST Department, where presentations encourage the reduction of student anxiety while preparing them for success in the classroom. Because repeat attendance is high, this program has evolved to include teachers, student teachers, and high school students as full contributors in ongoing OLC MST research projects and as principal investigators of student projects.

The "*Yuowanca*" grant also funded a one-day Science Exploratorium at the annual Lakota Nation Invitational Basketball Tournament. This event showcases the "best of the best" of all other outreach programs in a single venue, consisting of live, static, and passive exhibits on various science and engineering topics. Examples include: rock and fossil identification, sound activated wave generators, homemade single-seat hovercraft, 3D visualization of human anatomy, and the use of radio tracking devices to find chocolate turtle candies (demonstrating ornate box turtle tracking in the wild).

NSF (South Dakota) EPSCoR "Beyond 2015" and "2020 Vision"
These statewide programs promote and stimulate the formation of sustainable collaborations between the OLC MST Department and Pine Ridge Reservation's K-12 schools, funding OLC MST faculty visits to classrooms, presenting research, and field trips to points of scientific interest around the region. These activities involve OST MST faculty and staff, and they are well-attended by middle and high school students and teachers. The "2020 Vision" will continue to support programs formerly supported by "*Yuowanca*" (where the tipi poles come together) and "*Woniya Sa*" (red breath of protection), once they expire in 2016.

The SD EPSCoR estimates that OLC MST programs account for 40-60 percent of all of South Dakota's K-12 outreach. These activities are pursued because of their role in exposing students to science in general and to OLC MST in particular - a key reason for the existence of an academic "science pipeline" on the Pine Ridge Reservation. Despite the difficulties in assessing the efficacy of these programs, ample numbers of testimonials have been received from current and former students about how influential these experiences have been in the lives of K-12 students.

NASA Science, Engineering, and Math Aerospace Academy (SEMAA)
The SEMAA is a highly successful program that helps compensate for the lack of science instruction at K-12 schools. The OLC MST outreach staff visits K-12 school classrooms for an hour each week to conduct science demonstrations focused on NASA's science and engineering programs, including planetary science, astronomy, and aerospace engineering. Once each semester, each school brings students to OLC to connect to NASA programs via the Internet to experience a flight simulator, a wind tunnel, an inflatable planetarium, and star gazing through a large telescope. The grant also features a summer program for middle school students to have an opportunity to design, build, and roleplay a Mars colony (complete with radio communications and simulated social and scientific challenges) in the nearby South Dakota Badlands.

American Honda Foundation "Woniya Sa"
"*Woniya Sa*," or "red breath of protection" in Lakota, refers to the reddish coloration of newborn buffalo calves. The program overlapped and eventually succeeded NASA SEMAA, while expanding its scope to areas of science, other than space science and aerospace engineering. This program enhanced the most popular aspect of the NASA SEMAA program, the portable planetarium, by providing a larger, digital version of the planetarium.

Colorado State University (Ft. Collins) "Little Shop of Physics"
The OLC MST Department's STEM students have been involved with the Little Shop of Physics for the last seven years. Physics is taught in classrooms and at Pine Ridge Reservation school special events using hands-on activities with simple materials, covering topics in physics such as light, electricity, sound, and magnetism. An annual trip to Colorado State University in Fort Collins, Colorado, allows for building/replication/repair for new or existing experiments. While in Ft. Collins, OLC students practice using the exhibits on stage at events attended by several Denver-area schools. Little Shop of Physics participation directly influences students in pre-engineering, and the physics experiments are designed and built by students. The experiments are then cycled through reservation schools and put on exhibit in subsequent years.

The Reservation-Wide Science Fair: The OLC MST Department hosts an annual reservation-wide science fair. The 2016 fair was the largest one thus far, with 135 projects and 611 participants. The projects came from twelve of the sixteen schools on Pine Ridge Reservation and OLC students can be judges. Having K-12 students conducting science activities and experiments provides them with experiences to better solidify their backgrounds in the sciences, opening possible career opportunities. The fair will be supported by SD EPSCoR beginning in 2017.

WISCONSIN

As documented elsewhere, the College of Menominee Nation (CMN) was greatly impacted by their history with respect to “termination” of Federal status, especially in relationship to community outreach. This can be seen in efforts supporting their tribe’s contractual agreements with state governing agencies to supply education to tribal members, making it a State of Wisconsin school district. Because of this and migration of tribal members to urban settings such as Green Bay, Wisconsin, the efforts by this PEEC project have resulted in two areas of focus, the reservation campus and the branch campus in Green Bay. They have used a student-teaching-student approach with their Green Bay campus students mentoring K-12 students, a program they considered successful.

They also used somewhat unexpected resources, University of Minnesota professors, to come in to provide learning experiences for these K-12 students focusing on learner involvement and the “fun factor” that can be associated with learning mathematics and science fundamentals. These activities include such things as imploding a trash can or blowing objects out of a cannon. The visiting professors have taken the next step in preparing Green Bay students to perform demonstrations autonomously. The PEEC students have worked with the tribal high school to establish a chapter of American Indian Science and Engineering Society (AISES). In addition, there have been summer programming activities that include work on rocketry. This is all part of CMN’s support of the community through a “women-centered” approach, consistent with a traditional “keepers of the camp” role for women.

SUMMARY

Outreach between tribal colleges, K-12 systems, and mainstream institutions needs to vary just as much as the local typography or student situations change. That means that the key characteristic of the outreach effort needs to be flexibly combined with perseverance. Try many things and take advantage of those that work, and always try. Person-to-person contact seems to have the strongest influence in producing the best results. But this is not a “one and done” situation. To paraphrase Winston Churchill, never, never, never stop trying!

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Tours of industries located on or near the reservation allow students to gain hands-on experience. Here, the North Dakota PEEC students are touring the Enbridge tanker loading facility in Berthold, ND. (Photo credit: Robert Pieri)

9.

Establishing who leads: Hawaiian-serving community colleges or tribal colleges as leaders

G. Padmanabhan (ND), Hannan LaGarry (SD), Carol Davis (ND), Floyd McCoy (HI), Lane Azure (ND), Mark Hoffman (HI), and Charles Jason Tinant (SD)

INTRODUCTION

PEEC leadership involves respect, awareness, and sensitivity, among many other attributes, and it is manifested in a diverse set of activities. While all are critical to leadership in Native Hawaiian (NH) and Native American (NA) serving colleges, the foundation for contemporary education for these colleges must be related to a past upon which the future can be constructed. It is at that intersection where respect, awareness, and sensitivity are critical. There are two paths to follow, one from the culture-serving community, the other from the education-serving group. The merge can be magic – as it was at the PEEC effort at Windward Community College (WCC) in the University of Hawaiʻi (UH) System.

Leadership and evolution of tribal colleges

The tribal college movement that began in 1970's is still alive and evolving. Tribal colleges were the dreams of Native American (NA) leaders with the goal of providing a culturally relevant and nurturing environment on the reservation that many NA post-secondary students were not receiving at main stream schools, colleges, and universities. This chapter will address the leadership efforts of the PEECs (Pre-Engineering Education Collaboratives) advocating for indigenous populations in Hawaiʻi, North Dakota, South Dakota, and Wisconsin.

In 1973, the leaders of six tribal colleges came together to form the organization, American Indian Higher Education Consortium (AIHEC), to examine the status of tribal colleges and to chart their future. The six tribal colleges were DQ University (CA), Navajo Community College (AZ), Oglala

Lakota College (SD), Sinte Gleska Community College (now Sinte Gleska University) (SD), Standing Rock Community College (now Sitting Bull College) (ND), and Turtle Mountain Community College (ND). The vision that emerged for the role of tribal colleges included not only fighting poverty on the reservations but also preserving the cultural heritage, identity, and language for their respective tribes. Initially, each tribal college was required by funding sources to affiliate with state institutions that accredited the courses offered at their colleges. There was, however, inadequate local tribal college leadership in some cases that resulted in difficulty in gaining external recognition and accreditation for tribal colleges.

In 1978, with the passing of the Tribally Controlled Community College Assistance Act (TCCCAA), Public Law: 95-471, Title 1 legislation resulted in tribal colleges receiving an appropriation from Congress for direct support, based on tribal enrollment. Thereby, Federal agencies gave tribal colleges access to Federal funding. The appropriation also provided financial stability when tribal colleges sought accreditation. While the funding was welcome, financial support was never at the level recommended in the Federal legislation. The leadership of the tribal college presidents, individually and collectively since AIHEC, has been responsible for gaining broad recognition for the mission of tribal colleges.

The struggle for base funding continued, resulting in the passage of more Federal legislation, the Equity in Educational Land-Grant Status Act of 1994. Additional funding provided important support for research and outreach to communities, as well as movement toward granting higher-level degrees (Wheeler, 2004). At about the time that the Equity in Educational Land-Grant Act passed, the National Science Foundation (NSF) introduced an initiative that targeted tribal colleges, the Rural Systemic Initiative (RSI). Lura “Jody” Chase was the Program Officer at NSF, and Turtle Mountain Community College (TMCC) became the lead institution with Gerald “Carty” Monette, President of TMCC, as the Principal Investigator (PI). This program operated from 1994-2005 and spanned six states, 20 tribal colleges, and more than 100, K-12 schools on reservations in the service area. The result was an increase in STEM resources at the tribal college level, where base funding for STEM had been limited. The RSI program evolved into the NSF Tribal College and Universities Program (TCUP) that began in 2001 and is operational today. It is still under the direction of Chase, who has become a strong advocate for tribal colleges.

The problem continues concerning chronic underfunding and the continual need for support for operational funding. There are still issues to be resolved in advancing the mission and activities of tribal colleges in terms of their funding, identity, and stability. Reaping the benefits of some Western intellectual traditions, particularly in the area of sustainable ecology, the use of distance-learning technologies and multiculturalism still remain a challenge. Providing a smooth pathway for NA students to move from tribal colleges to mainstream universities and to be successful in acquiring four-year degrees in STEM disciplines, requires dedicated leadership at the tribal colleges and the mainstream universities in a meaningful collaborative framework with culturally sensitive pedagogy; community-oriented research and community outreach; and educational, financial, and social support systems.

STEM programs in tribal colleges

The focus of tribal college academic programs in their very early years was primarily to provide general education courses that would transfer to baccalaureate degree programs at other colleges and universities. The limited offerings in STEM courses were a consequence of limited resources and sometimes limited faculty. Their primary source of funding in the early 1970's was the U. S. Department of Education, Title III Program, that provided funding to developing institutions, and that linked tribal colleges to accredited colleges.

One of the missions of the tribal college movement was for such schools to be autonomous colleges. To acquire that status required a permanent funding source. The first leaders of the tribal college movement worked with Congress for years to achieve that funding goal. Monette (TMCC) was the President of the American Indian Higher Education Consortium (AIHEC) when Congress approved the TCCCAA of 1978. The TCCCAA gave tribal colleges a basic Federal funding source that was essential for sustainability. The funding allowed tribal colleges to move away from other institutions and to begin to offer their own programs of study. One condition required by the TCCCAA was that the tribal colleges needed to be accredited. To realize that goal, tribal colleges developed special relationships with regional accrediting agencies. Steve Crow, North Central Association of Colleges and Schools, offered guidance that enabled many tribal colleges to become independent accredited institutions of higher education. Once the tribal colleges were accredited and the TCCCAA funding source was in place, individual tribal college STEM efforts began to emerge.

TCUP and PEEC

While these prior early individual efforts enhanced STEM at tribal colleges, assistance to tribal colleges increased after President Bill Clinton signed an Executive Order in 1996 directing all Federal agencies to increase support to tribal colleges. The most significant STEM funding came from the NSF's Tribal Colleges and Universities Program (TCUP). The TCUP came under the direction of Chase, who had become familiar with tribal colleges through her involvement with the RSI. The TCUP program offered support for STEM education and other STEM initiatives within the nation's tribal colleges. Because of the success of TCUP, NSF eventually created a tribal college pre-engineering initiative called PEEC (Pre-Engineering Education Collaborative).

HAWAIʻI EXPERIENCE AT WINDWARD COMMUNITY COLLEGE

The WCC is one of ten campuses in this UH System, spread over six islands, four with undergraduate programs that lead to baccalaureate degrees, the remainder as community colleges awarding associate degrees. The main campus, UH-Mānoa, is also an internationally renowned, research R-1 university with graduate schools. Graduate degrees are also awarded at two other campuses. All are coordinated with courses readily transferred, not only between campuses, but also with articulation from two to four year-campuses, and it is here where PEEC has significance. This system provides a stunning array of opportunities for the education of students not only from Hawaiʻi, but also from elsewhere.

A PEEC student may start, for example, at Hawaiʻi's community colleges, such as at WCC. Here, awareness of a new professional world is struck, and a nascent interest is constructed. By its nature, PEEC involves every aspect of STEM; thus, a wide spectrum is presented to students from which new interests can find seed. It is here, where that interest is critically dependent upon leadership from the many scientific and cultural backgrounds that nurture these students, and how that merging of backgrounds can spawn the successful student. Cultural identity was crucial for success in PEEC, and it was incorporated through the unique programs at WCC that have foundations in the Hawaiian language and culture and its antiquity with implications for the future.

With PEEC as the example, the UH System provided relatively effortless internal transfers of students and articulation of courses. This combination, coupled with a WCC student body, comprised of almost a third Native Hawaiian (NH) students, led to the new focus of STEM as a place-based, culture-focused curriculum. Legislative acknowledgment and support for this curriculum resulted in upgraded and new educational facilities.

PEEC receives critical leadership and support from the state's university and college administrators. The PEEC effort has been a component in a variety of joint ventures among university campuses and departments (especially the College of Education; the School of Hawaiian Knowledge; and the School of Oceanography, Earth Science and Technology). The *Kahua A'o* project is an example of such a collaborative venture, whereby, historical Hawaiian newspapers were translated into English. An additional asset to this curriculum comes from other academic programs within the University of Hawai'i (UH) specifically a certificate program, the Marine Option Program (MOP). While one of a myriad of certificate programs today at UH, MOP was among the first having celebrated three decades of astounding success. Students, both undergraduate and graduate, participate as either research fellows or as interns with programs, projects, or concepts of their own. The relationship with PEEC works well. Here, for example, is the path for undergraduate students to enter the advanced world of existing works and projects, from engineering to science to politics to art to writing. With a certificate program established on most UH campuses, MOP also provides a significant and productive networking capability for students offering special assistance for the community college student transferring to a baccalaureate campus. A foundation has also evolved for obtaining financial support from local and national funding organizations and businesses.

The pre-engineering initiative at the UH community colleges was organized and funded via an NSF proposal in 2007-2008, under the aegis of Kapi'olani Community College (KCC) under the leadership of Robert Franco and John Rand, and for Windward Community College (WCC), Floyd McCoy (replaced later by Joseph Ciotti, due to an extended sabbatical leave). The PEEC at WCC has seen strong financial support from additional NSF funding (Title III, TCUP, and SENCER [Science Education for New Civic Engagements and Responsibilities] as well as from programs such as MOP, Pacific Center for Environmental Studies, Hawai'i NASA Space Grant Consortium, the Center for Aerospace Education, and others.

Today, the PEEC effort has set a guideline and example for articulation of students, courses, and programs within a particularly complex university system, geographically spread over six islands. Currently, guidance, support, and leadership continue among all campuses via active leadership and relationships through various faculty senates, academic committees, and administrators. Increasingly, this interaction is reaching beyond Hawai'i with international focus, incorporating a Hawaiian flavor and an exciting and promising future.

HAWAIʻI EXPERIENCE AT MAUI COLLEGE

PEEC provides a framework for collaboration between the UH-Maui College on the island of Maui, and UH community college campuses on the island of Oahu. A significant effort to utilize the UH System for the benefit of students on both islands was initiated and led by Kapiʻolani Community College (KCC).

The PEEC program on Maui consisted of curriculum development in the area of STEM associate degree pathways, Undergraduate Research Experience (URE), projects for undergraduate STEM students, and the Summer Engineering Experience (SEE2). Students were recruited from the Oahu colleges and selected for SEE2 by a collaborative effort from Maui- and Oahu-based personnel. Maui College faculty facilitated summer calculus classes in a hybrid emporium model, offering three sections of calculus classes to the summer cohort. Maui faculty and Maui Engineering Technology students designed and facilitated engineering workshops for the SEE2 Oahu students. These workshops introduced electronics laboratory fundamentals, while providing an engaging introduction to teamwork and project-based learning models.

In addition to summer calculus courses and summer engineering experiences, leaders provided students with cultural activities to reinforce team building and STEM interest. Students visited power plants and telescope facilities, as well as Hawaiian cultural sites.

During engineering projects, students provided feedback on faculty and peer mentor level of support. Students were generally satisfied to very satisfied (94 percent) with their SEE2 experience: 76 percent of the students also noted that SEE2 reinforced their decision to major in engineering, and 88 percent felt that the Huakaʻi experience (cultural experiences implemented every week) helped bridge a connection between engineering and Native Hawaiian culture.

One of the overall goals of the grant is to engage 170 students in all three Summer Experiences in Engineering (SEE). This number represents unduplicated cohort students who participated in SEE1, then SEE2, and then SEE3. This number actually represents 207 students when calculated as follows: 142 (SEE1 all years) + 170/5=34 (SEE2 only first year) + 155/5=31 (SEE3 only first year) = 207. To date, 310 students have participated in SEEs. The high completion rate is a result of the “fluidity” of the courses and cohorts, as well as recruitment and retention efforts.

Because each SEE offers at least two mathematics courses, students from different levels can attend. Furthermore, students who had been identified as engineering majors were engaged by coordinators in other ways if they could not participate in a SEE during a particular summer. Leaders recruited students for the following summers, depending upon their mathematics level. However, the 310 number reflects duplicate students who participated in any one of the SEEs. Since this number, 310, includes students who have returned to complete a second SEE, a better indicator is the number of unduplicated students who participated in SEE: 261, which represents a 126 percent completion. The completion rate is surprisingly high compared to the failure of keeping the original SEE1 cohort and leading them to SEE2 the following year and to SEE3 the year after.

Undergraduate Research Experience (URE) projects resulted in 98 student participants in research projects led by faculty members at their respective campuses. The students had the opportunity to conduct these projects in both laboratory and field environments. Because these numbers reflect two semesters and one summer, in some cases the same student may be duplicated in subsequent counts for continued semester participation.

The SEE1 and SEE2 students created posters representing experiences at their respective programs. The SEE1 students demonstrated how mathematics was used in electric guitar building, underwater robotics, and rocketry. They presented on the topics of harmonics, pressure, altitude, battery energy and motor power, voltage divider, buoyancy, and how Pythagorean ratio is used for fret spacing. The SEE2 students brought their amplifiers to demonstrate the various electrical and circuit concepts they learned at their summer session. They also presented their research posters on theory of amplifiers, wind power, Global Positioning System (GPS) use with hexacopters, and sound pitch synthesizers. The SEE3 students did not produce posters but provided the audience with oral presentations of the outcomes of their research experience. The wide range of topics included the use of microcontroller in fashion technology, landslide early warning systems, wave energy, solar power, touch free robotics, electric vehicle, bioreactor for wastewater treatment and biofuel production, and wireless Arduino clones. In addition, many ‘IKE students engaged in URE throughout the year, also presented their research and provided demonstrations of their work as follows: Cansat unmanned surface vessels, self-powered biosensors, semi-autonomous mining rover, air rocket payload, and underwater robotics. A total of 78 students participated and presented at the symposium. In addition, ten administrators across the UH system, 35 faculty members and mentors supporting their students, twelve community partners, and 61 family members also attended the symposium, for a cumulative total of 166.

The overall experience for faculty, researchers, and participants was positive and helped to build closer personal relationships between the people based on Maui and Oahu. They faced challenges with a spirit of cooperation, and they implemented solutions across several campuses in order to better serve the students as a UH System, rather than at independent colleges. A new collaborative structure and attitude emerged as the project moved forward and matured. The end result is that UH has now implemented a pre-engineering pathway as an Associate in Science in Natural Science Degree (ASNS) degree option, and is now promoting this option to students on both Maui and Oahu. This new pathway and emphasis would not have been possible without the funding of the PEEC project and the guidance of the PEEC project participants.

NORTH DAKOTA EXPERIENCES

North Dakota tribal colleges: The beginning

The North Dakota (ND) tribal college movement has its origin in the Department of Education Talent Search Program. In 1971, the University of Mary added Talent Search to their Student Support Services Program. Both projects focused on Native American (NA) students, primarily from ND. The Program Director was Fred Baker, an enrolled member of the Three Affiliated Tribes. The Director of the Talent Search Program was Carol Davis. She was headquartered on the Turtle Mountain Reservation, and each of the North Dakota reservations had a counselor, as follows: Phyllis Howard at Fort Berthold, Jerry Silk at Standing Rock, Gertie Cavanaugh at Spirit Lake, and Sherman Brunelle at Turtle Mountain. Their primary responsibility was to recruit tribal members to attend higher education programs or help them to gain GED’s so they could qualify to enroll in higher education. In addition to the counselors, the program had an advisory committee that consisted of people from the four reservations. Although the program was funded through the University of Mary (Mary College at that time), the Talent Search program helped students enroll in the colleges, universities, and vocational schools of their choice.

When reviewing the 1971 data, the Talent Search staff was dismayed at the large numbers of students from the four ND reservations who enrolled in colleges and dropped out a month or so later. Besides causing tribal students to experience failure, the tribal scholarship programs were spending significant funds, and the tribes were getting very little in return. Some students were successful, but an alarming number were not. Another problem was that when tribal members attended state colleges and universities, they were not able to learn about their own culture or government issues or structures. When they came back to work on the reservation, they had to learn about sovereign nations and how to maneuver in that system.

At about this same time, across Indian country, information about an exciting new venture surfaced. In 1968, the Navajo Nation established Navajo Community College, which became the first tribal college located on an NA reservation. As the ND Talent Search Director and staff lamented over the dismal higher education statistics on four North Dakota reservations, they noted the Navajos' example of success.

On a national level, the ND Talent Search Director, Carol Davis, met other state Talent Search directors from across Indian country and forged an especially strong alliance with the South Dakota (SD) State Director, Birgil Kills Straight, who headquartered his Talent Search program on the Pine Ridge Reservation. Soon, the discussion of the need for a change in higher education for reservation students became a focus of their attention. As their discussions progressed, they agreed that the change they envisioned was a system governed by tribal governments that brought tribal history and culture to the forefront. Communication with Navajo Community College helped those interested in the possibility of tribal control of higher education to realize that the establishment of tribal colleges could be a reality. This set the foundation for tribal college development in ND and SD. Interestingly, the word "community" seemed a good fit for the reservations, since the founders sought to design a higher education system on their respective reservations.

To get the initiative started on the Turtle Mountain Reservation, the Talent Search staff approached the Tribal Council to discuss the option. Gregory LaVallie, Tribal Chairman, liked the idea and created a committee by resolution to pursue the venture. The committee consisted of Carol Davis, Sherman Brunelle, and Gary Nadeau (Talent Search); Lynn Davis (college student); Pat Gailfus, Janice Schlenvogt, and Lance Azure (Indian Health Service); Allen Allery and Bonnie Davis (Cultural Program); Jack Fiddler and Roger DeCoteau (Drug and Alcohol Program); Resa Davis (Post Office employee); Elma Wilkie and Wayne Keplin (Tribal employees); and Beverly Albert (Bureau of Indian Affairs school employee). The committee was excited about the opportunity and worked diligently to help create the college.

As much as the term “community college” was a good fit for the ND reservations, it was not well accepted in their next move. The Talent Search Director communicated with Gerald One Feather (Pine Ridge) about what they heard was being proposed for the start-up of tribal colleges. He advised them to find an accredited college that would be willing to work with them. This accredited college would actually certify the tribal college’s credits. In fact, he offered to have them join a SD college where Oglala Lakota College (OLC) was getting their courses certified. When this was discussed with the Turtle Mountain Committee, it was decided that they wanted to work with North Dakota State University (NDSU)-Bottineau Branch. A visit with the Dean of the Bottineau Branch was fruitful, but there was work to do. The Dean informed the committee that the ND State Board of Higher Education (NDSBHE) would have to approve the request. They gained a place on the agenda for the next meeting.

Lynn and Carol Davis attended that NDSBHE meeting at the Holiday Inn in Minot, ND. They were last on the agenda, and it was midnight when they walked into the meeting. Carol Davis explained their reason for requesting the meeting. One of the board members asked if Turtle Mountain would be willing to take control of one of the existing state colleges. Carol Davis said, “No!” She was sent by the committee to ask for an education site on the Turtle Mountain Reservation. Accepting a state university would not meet the needs they had identified. One opposing argument was in response to a law passed by the ND State Legislature that was against establishing any new colleges. There were board members who wanted to approve the request, and that proved helpful, bringing enough minds together to consider how to circumvent the legislative directive. After much discussion, Turtle Mountain Community College would not be identified as a new college. Instead, it would be identified as the Turtle Mountain Enrichment Center and NDSU-Bottineau Branch would loan their accreditation to the venture. The groundwork began falling into place.

After the Minot meeting, Carol Davis drove to Standing Rock Reservation to meet with David Gipp, the tribal planner. He was ready to put a plan into action for a college for Standing Rock Reservation, and they eventually teamed with Bismarck State College to accredit their courses. David Gipp’s brother, Bob Gipp, was on their founding committee, along with Jerry Silk, the Talent Search Counselor. Other committee members were Glen Eagle from Wakpala; Emma Jean Blue Earth from Cannonball; and Menard White, who worked in tribal education. Standing Rock Reservation had a good team, and, like Turtle Mountain, they were ready to take the next step.

During the fall of 1972, a telephone call from Birgil Kills Straight to Carol Davis turned out to be critical. He told her that a meeting of the National Indian Education Association was taking place in Seattle, Washington, in two weeks, and there would be an effort by tribal people attending the meeting to establish an organization of tribes that aspired to establish tribal colleges. In addition, they would be meeting with Helen Sherbeck, Director of Title III, Developing Institutions, at the US Department of Education. She was a member of the Lumbee Tribe of North Carolina and was very interested in what tribes wanted to do in higher education.

Carol Davis knew that the ND tribes had to be at the table. Because the Talent Search Program did not have funds to pay for her travel to the meeting, she realized she would have to pay her own way. At the time, her husband was a college student, and she was the sole provider for her family including four small children. Spending her entire salary to travel to the meeting could mean hardship at home. Yet, missing the meeting could mean that the Turtle Mountain Band of Chippewa and the other ND tribes might be left out if the initiative went on without them. She bought the airplane ticket and went to Seattle.

The glamour of the meeting's hotel in Seattle was new to Carol Davis. She had only been in one other hotel in her life. That had been in Aberdeen, SD, at a time when she was attending an NA boarding school on the Yankton Sioux Reservation at Marty, SD. It was an old hotel that had but one bathroom at the end of the hall. In fact, when she booked her room, she asked the reservation office if it would be possible to have a room with a bathroom in it because she did not want to walk down the hall to the bathroom among strangers. The clerk at the other end of the conversation chuckled and replied, "Madame, all of our rooms have private bathrooms!" Relief! The humor of that conversation was not appreciated until several years later.

Carol Davis followed several people around the Seattle hotel for two days, but she was not successful in getting an invitation to the meeting, although she talked to key people several times. On the morning of the last day of the conference, she was informed by Patricia Locke from the Standing Rock Reservation that the meeting had taken place that morning, and she directed Carol Davis to Gerald One Feather from Pine Ridge Reservation. He told Carol that there would be a consortium of tribal colleges formed. There would be four tribes participating: Navajo Community College (Tsaile, AZ), DQ University (CA), Oglala Lakota Community College (Kyle, SD), and Sinte Gleska Community College (Mission, SD). Their plan included providing planning status to Turtle Mountain Community College (Belcourt, ND) and Standing Rock Community College (Fort Yates, ND). Carol Davis made her case for full participation for Turtle Mountain and Standing Rock. “We don’t need a planning grant at Turtle Mountain or Standing Rock. We have active programs that are ready to go”, she said to Gerald One Feather. He asked if they had proposals, and she assured him that they did. “Show up in Phoenix with your proposal in two weeks and you are in!” was One Feather’s response.

Carol Davis was elated for a few minutes and then she asked herself, “How do you write a proposal?” Carol had seen proposals but had never written one, let alone paid attention to the format. But she packed her bag and began her trip home to the Turtle Mountain Reservation where she was confident that things would fall into place.

She boarded the plane and thought about the long flight home to ND. She was not about to waste it. She did not have any writing paper, but she called the stewardess and asked for a supply of napkins to take notes. She began to write. Her process was simple. She thought about the funding agency reading her proposal.

“Who are we?” “How do we know that there is a need?” “Do we have students ready to enroll?” “What do we want to do?” “How will we know when we are successful?” The late arrival of the plane in Minot, ND, provided Carol with enough time to complete the first draft.

A tribal resolution in November 1972 created Turtle Mountain Community College. Dave Gipp led the Standing Rock Tribe into the same process. Two weeks later, Elma Wilkie and Wayne Keplin (tribal employees), who were Turtle Mountain Community College Committee members, carried Turtle Mountain’s proposal to Phoenix, Arizona, where Turtle Mountain was admitted into the American Indian Higher Education Consortium (AIHEC). Dave Gipp took charge at Standing Rock. Menard White and David Gipp (tribal employees) went to Phoenix, AZ, with their documents, and they were also admitted into the AIHEC. To assure that the union would be strong, a tribal ceremony took place, thus earning them status as spiritual institutions. At Phoenix, the AIHEC was founded by six tribal colleges. Once in place, the consortium began to assist other tribes in establishing their own institutions of higher education. Fort Berthold came into the consortium under the direction of Phyllis Howard. Spirit Lake eventually established their college and made the circle complete in ND, where all of the tribes now have colleges under their control.

How leadership evolved in the North Dakota PEEC

In the mid-1990's, a strong collaboration emerged in ND among the tribal colleges' Academic Deans from Turtle Mountain Community College (Carol Davis), Cankdeska Cikana Community College (Erich Longie), Nueta Hidatsa Sahnish College (formerly Fort Berthold Community College) (President Liz Yellowbird), Sitting Bull College (Laurel Vermillion), and United Tribes Technical College (Bennett Yellowbird). As their partnership grew, so did their effort to address their concerns. Among their issues was the low enrollment in STEM. It was 1998, and they were aware that the workforce had many opportunities available in STEM, although the NA students enrolled at the tribal colleges were not declaring STEM majors.

At about this same time, Salish Kootenai College of Montana hosted a conference in Rapid City, SD, for the tribal colleges and universities that were participating in the All Nations Alliance for Minority Participation (AMP) program. At one of the sessions, they seated the participants by states. The ND table was filled with STEM representatives that included G. Padmanabhan from the College of Engineering at NDSU and Carol Davis from Turtle Mountain Community College. Davis mentioned to Padmanabhan that her son, Danny, was an engineering student at NDSU. To her surprise, Padmanabhan was Danny's advisor. Davis and Padmanabhan soon found themselves in a conversation about pursuing opportunities to increase enrollment and the success of NA students in tribal college STEM programs. Little did the two realize that their casual conversation would lead to a long and sustained effort to improve STEM opportunities for students at the ND tribal colleges.

Soon after return from the AMP conference at Rapid City, SD, the tribal college academic deans and Padmanabhan continued the conversation and worked hard to bring about a partnership between the five ND tribal colleges and the NDSU College of Engineering. The collaboration soon became a reality, due to the cooperative efforts of a few NDSU engineering faculty and the academic deans of five ND tribal colleges. A project was funded by the Office of Naval Research to develop a culturally-relevant model designed to create a pathway to STEM careers for NA students residing on the four ND reservations and in the Bismarck community near United Tribes Technical College.

The pathway extended from middle to high school, to the tribal college, to the university undergraduate and graduate school, and to job placement of NA students. University and tribal college faculty, tribal high school teachers, and culture teachers were collaboratively involved in developing and delivering lesson plans and in creating a nurturing environment in a continuous pathway to attract and to retain students in STEM disciplines. It is a model of collective leadership that has proven to be successful (Davis, et al., 2000; Lin, et al., 2007a, 2007b; Padmanabhan, et al., 2002, 2004, 2006, and 2011).

The ND PEEC leadership was a natural evolution of the collaborative framework that developed during the Nurturing American Tribal Undergraduate Research Education (NATURE) program (Davis, 2008) and its predecessor programs. The NATURE program offered plenty of opportunities on a continual basis for the interaction of engineering and science faculty at NDSU and tribal college STEM faculty. Mutual visits by the NDSU and tribal college faculty at their campuses during NATURE activities such as Sunday Academy and summer camps proved to be critical in strengthening the collaboration at the faculty level. This collaborative effort was further enhanced by one of the NDSU engineering professors, Robert Pieri, serving Turtle Mountain Community College (TMCC) on a one-year sabbatical.

Another STEM leader, Lane Azure, who emerged from the ranks at the Cankdeska Cikana Community College (CCCC,) provided Pieri with substantial leverage for both the NATURE and PEEC projects. An enrolled member of the Turtle Mountain Band of Chippewa, Azure was well versed in enthusiasm, academics, and leadership and was versatile in curriculum, education, STEM, and NA culture. Azure's ND work ethic and secondary education background led him to the NATURE project in 2008. Having an existing relationship with Carol Davis and Carty Monette, Azure met Padmanabhan and Pieri. Pieri is the Principal Investigator (PI) of the NDSU part of the ND PEEC. His constant contacts with the ND tribal college administrators, through the above-mentioned college campus visits, enabled him to be an effective leader in the collaborative. During the PEEC proposal writing process, Pieri and Padmanabhan reached out to Azure for his leadership at CCCC. A TCUP solicitation required a tribal college to be the lead in the collaboration, and Azure gladly accepted for CCCC. After the award announcement, the collaboration utilized each of the tribal college Chief Academic Officers (CAO) as project investigators and advisory group members for each of the tribal colleges (Sitting Bull College, Nueta Hidatsa Sahnish College, Turtle Mountain Community College, and Cankdeska Cikana Community College). In addition, Azure inherently played the role of director for the lead college and did much of the heavy work for the CAO team. This was another added value for the ND PEEC partnership.

During the inception of the project, the young team (Pieri, Azure, and newly graduated engineer Ann Vallie) began by bringing together the advisory group. The team found it necessary to conduct a needs assessment to help establish a plan of action for the ND PEEC project. Highest on the list of outcomes was establishing a pre-engineering curriculum that would allow tribal college students to compete, with the hope that they would be able to enroll in either of the mainstream engineering colleges in ND as a junior (3^{rd} year) engineering student. The uniqueness of each of the tribal colleges in ND created challenges for the PEEC project, since each of the colleges requires a tribal cultural component for acquiring an Associate's degree.

The next item for the team was to be able to have a pre-engineering degree that would matriculate to a 4-year institution that met the cultural components of each tribal college, but which also had fully qualified faculty to deliver such a rigorous curriculum. New standards by the Higher Learning Commission require a faculty member of a two-year institution to hold a Master's degree in the discipline they teach, or at least 18 credits in the field they teach. In addition, NDSU is an engineering school that also adheres to Accreditation Board for Engineering & Technology (ABET). The ABET accreditation provides assurance that a college or university program meets the quality standards of the profession for which that program prepares graduates; therefore, Pieri was valiant in assuring that the ND PEEC was also adhering to these criterion.

In January 2010, the program began offering its first courses over the Interactive Video Network (IVN) using the two faculty members hired for Cankdeska Cikana Community College (CCCC) and Turtle Mountain Community College (TMCC). The two other partners Sitting Bull College (SBC), and Nueta Hidatsa Sahnish College (NHSC), were not far behind in hiring qualified engineering faculty to assist in delivering the curriculum to the first cohort of PEEC students. As time progressed, additional challenges emerged but were overcome by the evolving team. An external and objective view was sought from external evaluator Joan LaFrance of Mekinak Consulting. One of the most apparent concerns of the program came from the students who indicated that a personal touch was missing through the IVN. The team soon found it necessary to have the faculty members rotate to each of their classroom satellites to establish rapport with their students. In addition, Pieri established a common place for all of the PEEC students and faculty members to meet and greet, but mostly to work on a common core project that developed a bond among the students, staff, and faculty.

Although the institutional administrations were generally supportive of the concepts to begin with, enthusiasm appeared to fade as the project progressed. That may be due to the inherent conflicts in the policies of individual institutions to handle various components of the project, particularly at the implementation stage.

The ND PEEC program is unique in the sense that the collaborative consisted of four tribal colleges and a mainstream university with a PI and Co-PI for each site and separate budgets for each site. The framework allowed the ND PEEC to develop and offer courses with transferrable credits among the institutions. Courses were shared through distance education mode or by on-site offerings.

SOUTH DAKOTA EXPERIENCES

How leadership evolved at the tribal college, OLC, in the South Dakota PEEC

Oglala Lakota College's (OLC's) Math, Science, and Technology (MST) Department was expanded in the mid-1990's with a grant from NSF's Model Institutions of Excellence (MIE) program, which funded STEM faculty, distance education equipment, student research assistantships, and the building of the Lakota Center for Science and Technology (LCST). Substantial awards from the NSF's Tribal Colleges and Universities Program (TCUP) and the Academic Research Infrastructure (ARI) program, provided laboratory equipment, and continuing support for research faculty, student research assistantships, and K-12 STEM outreach support that have sustained the OLC MST Department to the present day. The TCUP funding helped to establish the OLC MST Department's baccalaureate degrees in Natural Science, and A.A. transfer degrees in Life Science and Science Engineering and Mathematics.

Charles Jason Tinant and Hannan LaGarry assumed OLC MST Departmental leadership in 2007-2008. They realigned departmental research activities to focus on understanding the Pine Ridge Reservation's natural environment, and to partner with tribal environmental programs to support monitoring and data-analysis needs. Faculty research activities in prior years had been focused on the development of a business model to develop an analytical laboratory, and outreach activities were closely aligned with the NASA Science Engineering Mathematics Aerospace Academy (SEMAA) program. Expanding reservation-based research into the classroom to attract a greater number of students as research assistants formed the basis of the OLC pre-engineering constructivist teaching approach.

The model for the Oglala Lakota College, South Dakota State University, South Dakota School of Mines and Technology Pre-Engineering Education Collaborative (OSSPEEC) was originally envisioned by Tinant, Eric Krantz of RESPEC (an engineering consulting firm), and Bruce Berdanier (formerly of SDSU) while engaged in a water resources engineering project sponsored by Rotary International for Hospital Albert Schweitzer in Deschappeles, Haiti. The Haiti project was implemented to map the existing water distribution system for the hospital and surrounding communities, and to help with the design of a new water distribution system to meet then-current community water resources needs. Unanticipated outcomes of the project were that both Tinant and Krantz enrolled in a Civil Engineering (water resources) Master's program the following fall, and Berdanier continued to sponsor international service learning projects (Berdanier, et al., 2009).

The OSSPEEC project was reimagined a decade later by C. Jason Tinant (OLC), Foster Sawyer (SDSMT), and M.R. Hansen (SDSMT) during a sandstorm, while in southern Mongolia. The team was on their second trip to Mongolia in two years. Bruce Berdanier, Tinant, and Hansen had received prior year NSF funding to study the transport and fate of tailings from a copper-molybdenum mine in Erdenet, Mongolia, with undergraduate students and faculty from the Erdenet Institute of Technology (EIT). The collaboration resulted in the First International Conference on Mining and Technology in Erdenet (Tinant, et al., 2009 & Sawyer & Tinant, 2009), which was co-funded by EIT and the Erdenet Copper Mine, and led to Mongolia's adopting water quality regulations to reduce off-site mining impacts. During the sandstorm, Tinant, Sawyer, and Hansen had asked one another, "If NSF can invest in faculty-student research experiences in Mongolia to solve multi-faceted environmental problems abroad, then why can't NSF invest in solving multi-faceted environmental problems at home on Indian reservations?" And, NSF was listening.

During 2009, while attending an NSF TCUP Tribal College Workshop, OLC faculty members Tinant and LaGarry were made aware of a Pre-Engineering Education Collaborative (PEEC) program for tribal colleges as leads in a multi-institutional consortium. Following the conference, the engineering faculty from research experiences in Haiti and Mongolia formed the original OSSPEEC project leadership. The leadership team envisioned three goals for OSSPEEC: 1) establishing collaborative offerings of the first two years of engineering curricula, coupled with on-reservation hands-on laboratory experiences and recitation sessions at OLC; 2) transforming classical engineering program curricula to follow the constructivist philosophy incorporating project-based service learning and research experiences; and

3) increasing the pre-engineering and engineering recruitment, retention, and graduation rates for SD's Native American students.

The current leadership structure for the South Dakota PEEC

South Dakota's PEEC leadership team membership has varied over the years of the project as members retired or were promoted to positions of greater authority. However, with each change in the leadership roster, the project evolved to continue its core mission of constructivist teaching, research, and experiential learning. James Sanovia, a member of the Rosebud Sioux Tribe, matriculated from the OLC SEM program to SDSMT, where he graduated with a degree in geological engineering and is currently a Master's graduate student, was recruited to teach geological engineering coursework at OLC. Jennifer Benning (SDSMT faculty) was recruited to create greater opportunities for students wanting to conduct research in sustainability engineering. Dan Dolan (SDSMT faculty) was recruited to work with students wanting to matriculate into mechanical engineering programs. Anthropologist Richard Meyers (SDSU faculty), a member of the Oglala Sioux Tribe, was recruited to provide a leadership voice from the NA community. Suzette Burckhard (SDSU faculty) was recruited to anchor the program at SDSU, and for her water resources engineering and engineering outreach experience.

While each faculty member from OLC, SDSU, and SDSMT brings discipline-based experience and expertise, the direction of OSSPEEC research was established by student and faculty members meeting with community leaders to ask about their research needs. The research agenda established in the initial year of the project was centered on student and community member concerns about water resource sustainability, naturally-occurring uranium and potential impacts from a uranium mine near the Pine Ridge Reservation boundary, and wind energy production. The research agenda has evolved to address student and community leader interests in sustainable local food production, providing affordable housing, and greater cooperation in GIS-remote sensing projects between the tribe and OLC.

Because OSSPEEC was centered on the goals of building pre-engineering capacity at OLC, experiential engineering research to meet reservation needs, and graduating more Native American engineers, OLC faculty have had a central role in guiding the evolution of the project at OLC and on the Pine Ridge Reservation.

The greatest catalyst, however, to OSSPEEC's meeting its more ambitious goal of transforming classical engineering program curricula by incorporating project-based service learning and research experiences, has come from the leadership efforts of the students. They have used their PEEC experiences to achieve national recognition as Udall Scholars, Truman Scholars, and to receive REU fellowships at MIT and Harvard, and some have been asked to give TED talks. Their individual successes have led to their being recognized as current and future leaders in the community, in student government, and on race-relations boards with the Rapid City, SD, police force. Their collective achievements may be, in part, responsible for increased administrative support at OLC and SDSMT. During the later years of OSSPEEC, applied research was added to the OLC Mission Statement, and the SDSMT president has strongly supported implementation of an Engineering in Community Service (EPICS) program (NSF grant 1525831) (PI, Jennifer Benning, SDSMT).

The impact of leadership on developing programs in STEM disciplines in South Dakota

The SD PEEC leadership team has always focused on a forward-looking program that engages students where they are. This requires a leadership with vision. The goal is to have NA students successfully complete preliminary coursework leading to an Associate's degree, find and become familiar with an intellectual and professional community of peers (for example, SDSU or SDSMT), and then transition to this same university at a distant location, and complete a Bachelor's degree. The leadership aims to include persons who are more than just acquirers and spenders of money, administrators, or content providers. The leaders of such an enterprise need to be focused, adaptable, and ready to serve as a champion of that aim, regardless of administrative and financial obstacles.

The hallmarks of the OLC program are that research and experiential learning projects are as follows:

- place-based (with local experts who know the reservation),
- self-selected (promotes ownership and engagement),
- constructivist (focuses on the research or service experience),
- grounded in Lakota culture (promotes a conservationist or preservationist ethos that preserves the sacredness of *Unci Maka*, Mother Earth),
- based on a philosophy of non-abandonment (such that students with complex and challenging lives can exit and re-enter the program at any time and not be penalized, excluded, or "weeded out." To this end, the leadership needs an unfailing and enduring

faith in the students and a tireless commitment to the goals of the program (Tinant, et al., 2014; and Kant, et al., 2014).

The impact of leadership on maintaining the cultural/community identity in STEM curricula and programs in South Dakota

Lakota society is organized into large, extended family groups called *tiospaye*. *Tiospaye* members have the benefit of a large support network and the responsibility to support the other members. Lakota culture is also a collective. Decisions are typically based on consensus, and ideally, every voice, especially dissenting ones, are heard fully and completely. Lakota culture is stratified by age and typically not by appointed authority (unless reached by tribal consensus). Tribal Elders are the keepers of tradition, preservers of culture.

The OLC's defining purpose is to preserve, utilize, and transmit Lakota culture to improve life on Pine Ridge Reservation. But, maintaining a cultural and community identity is, in some ways, a challenge for the SD PEEC program, since much of the project leadership is non-Native. The OSSPEEC leadership recognizes the importance of adopting a Lakota leadership perspective, and they rely on students, stakeholders, and communities to share Lakota perspectives through language and philosophy. Some of the Lakota viewpoints that have helped the SD PEEC to evolve include thinking as members of a *tiospaye*, and adopting consensus-based decision-making. Wherever possible, Elders are consulted, and their thoughts and opinions were and are heavily weighed and considered. The OLC has adopted annual "listening sessions" to which all stakeholders are invited. During these sessions stakeholders describe needs, priorities, and limitations. Following each stakeholder's presentation, the PEEC leadership team has responded with their current ability to address the speakers, and with suggested modifications to the SD PEEC program to better serve that stakeholder.

South Dakota reflection

Most of those associated with the SD PEEC program, including faculty, staff, students, and administrators, consider it a success. This is largely because of the vision of the kind of program desired. Ideally, students passing through the SD PEEC program leave it with a stronger feeling of self-reliance, a clearer understanding of what it means to be an engineer in both mainstream and reservation society, the confidence that there is an intellectual and professional space in the world where they can be accepted and fit in, and they often gain the beginnings of an identity as a STEM professional. These are the attributes that will enable the students to be successful.

WISCONSIN EXPERIENCES (based upon interviews with CMN PI Diana Morris)

In the College of Menominee Nation (CMN), PEEC leaders have been fortunate to work with true partners who ask, “What can we do?” It is important for mainstream colleges and universities to work with the tribal colleges as equal partners in addressing issues such as STEM curricular development and capacity building in research and STEM education at the tribal college, while preserving cultural relevance and emphasis. A true and meaningful collaborative is the key. With this idea in mind, CMN PEEC leaders mandated that collaborators in the University of Wisconsin system faculty work together at all three schools involved in their PEEC (CMN, University of Wisconsin-Madison [UW-M], and University of Wisconsin-Platteville [UW-P]). They are working to articulate the two systems (CMN and UW) through agreements, so that credits transfer.

Prior to the Wisconsin PEEC, CMN had several collaborations in non-engineering areas with UW-M and UW-P. For example, CMN PI Diana Morris had a collaborative project with UW-M but not with UW-P. Math, chemistry, biology, and engineering faculty at CMN participated in STEM projects.

The departments in CMN are mostly single-faculty departments. Typically the ideas for starting new programs do not originate from individual departments, but they come from administrators. The administrators reach out to mainstream universities for collaboration first, and then they bring CMN faculty into the framework. For projects of these types, some funding agencies require administrators to be the PIs. Some faculty, after gaining adequate experience, could take the role of PI. For example, at CMN, Diana Morris (Chief Academic Officer) was the PI; Lisa Bosman (Engineering faculty) was in charge of programming for the project; and Chad Waukechon (Dean, Letters and Science) was in charge of oversight.

CONCLUSIONS

This chapter provides highlights of leadership efforts at Native Hawaiian (NH)-serving and tribal colleges, and the mainstream universities that supported them within PEEC.

The tribal college movement that began in 1970’s is still alive and evolving. The struggles and successes of NH-serving and tribal college leaders over the years have helped to fulfill the dreams of the founders of those colleges. Through the dedication and efforts of many individuals to provide a culturally relevant and nurturing environment for Native post-secondary students, many lives have been enriched. In addition, many state university STEM faculty have gained an understanding of Native culture in the states where they reside and beyond.

Leadership matters. The positive impact of NH and tribal leadership is evident all the way from the founding of NH-serving and tribal colleges to currently successful STEM programs, including PEEC. Preserving cultural identity and practices, while advancing STEM in the curricula for NH and Native American (NA) students, has been a challenging element for PEEC leadership at both Hawaiian-serving and tribal colleges, and also for the mainstream universities that collaborate. Successful STEM programs in NH-serving and tribal colleges derive their strength from leadership partners at all levels -- administrative, faculty, students, and community. The collaboratives work best when based on mutual respect, cultural awareness, and sensitivity.

In the future, as a best practice, NH-serving and tribal colleges may want to consider institutionalizing a STEM leadership position or making it a permanent part of the job description of a key staff member to coordinate all levels of services needed to carry out a successful STEM program.

Enrollment is likely to increase in the Associate of Science and Bachelor degree programs when these collaborations exist at tribal colleges. For example, enrollment in the Associate of Science Program at Turtle Mountain Community College in ND increased from 31 students in 1998 to 187 students in 2007. This was the intensive period when several collaborations between the tribal college and mainstream universities were ongoing (Davis, 2008).

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Hawai‘i students at the Marine Education Training Center studying vessels, including a double-hulled voyaging canoe. (Photo credit: Hannah Aldridge)

10.

Discovering how and how well Native-Hawaiian community colleges work with a mainstream university in Hawai‘i

Robert Franco (HI) and John Rand (HI)

INTRODUCTION

This chapter looks at how Tribal Colleges and Universities Program (TCUP) colleges and universities developed sustained and authentic partnerships with their mainstream university partners.

HAWAI‘I PEEC

The Hawai‘i PEEC initiative brought together five community colleges, four on the island of O‘ahu: Honolulu, Kapi‘olani, Leeward, and Windward; as well as a fifth, Maui College, on the island of Maui. The purpose was to educate and to transfer a growing number of Native Hawaiian (NH) and other underrepresented students to the University of Hawai‘i at Mānoa College of Engineering (UH-M COE).

Discovering how to work together

Kapi‘olani Community College (KCC) developed its Associate in Science in Natural Science (ASNS) degree in 2009, and it was later adopted by all six other University of Hawai‘i (UH) community colleges statewide. The ASNS degree program includes students with pre-transfer concentrations in physical science, life science, engineering and information and communication technology. These concentrations enable students to identify and transfer efficiently into baccalaureate majors. Prior to the PEEC grant in 2010, a small number of Native Hawaiian (NH) community college students were transferring to the UH-M COE and were receiving support there from the Native Hawaiian Engineering and Science Mentoring Program. These transfers and support programs created positive relationships across the Hawai’i PEEC campuses, and relationships were further cultivated during the PEEC project.

Many of the STEM faculty at the community colleges had completed Master's and Doctoral degrees at the University of Hawai'i at Mānoa (UH-M), and they maintained collegial research relationships with their faculty advisors. For example, of the 17 Ph.D. scientists at Kapi'olani, thirteen received their Doctoral degrees from UH-M. The engineering faculty at the community colleges were able to build trusting relationships with their UH-M colleagues and to conduct a collaborative review of curriculum to develop a single set of pre-engineering core courses that provided a foundation for transfer into civil, electrical, and mechanical engineering. Previously, each of the fields within engineering had a different set of core courses, and this diversity resulted in frequently under-enrolled and then cancelled courses along the engineering transfer pathway.

Faculty and students at both the lower-division two-year campuses and the upper-division UH-M campus developed a set of integrated, inter-institutional projects, including undergraduate research experiences in small groups. Kapi'olani and UH-M faculty and students participated in a two-day symposium sponsored by NSF SENCER entitled, "Resources, Energy, and Island Sustainability" in October 2010. This symposium brought together faculty practitioners in undergraduate research and service-learning and community engagement from the following UH programs: *Mālama i nā Ahupua'a* (watershed conservation), *Mālama Maunalua* (coral reef conservation), Lyon Arboretum, Waikiki Aquarium, UH-M COE, and Hawai'i EPSCoR. The participants discussed urgent issues of climate change, sea level rise, ocean acidification, groundwater resources, invasive species, and restoring endemic and indigenous flora. Such discussion further built relationships of trust and respect across the participating campuses.

At the same time, administrators at the campuses developed efficient and effective transfer agreements, provided access to mainstream advisors prior to transfer, identified student eligibility for scholarships upon transfer, established automatic admission with a GPA of 2.0 or higher, and developed a reverse transfer system through which students completing courses at UH-M that met ASNS requirements were awarded that degree post-transfer.

As a result of these relationships, Hawai'i implemented: 1) an effective transfer pathway to UH-M COE through a two-year degree (ASNS) in pre-engineering currently implemented at Leeward, Windward, and Kapi'olani Community Colleges; and 2) a shared 39-credit pre-engineering curriculum across six campuses with 85 percent of the curriculum online. The program has engaged and retained 385 students: 162 currently in community colleges, 85 transferred to UH-M; 69 obtained an Associate degree; and 51 obtained a Bachelor of Sciences in Engineering.

Other effective strategies used in Hawai‘i

One of the biggest challenges facing an emerging pre-engineering program is low enrollment in engineering courses. This enrollment challenge is particularly true for sequenced courses such as calculus 1, 2, and 3 or multiple-semester physics courses. If a course needs to be cancelled because of low enrollment, it often disrupts the sequencing of pre-engineering courses and ultimately threatens the students' progress and the entire program. In the early years of the PEEC program, sustained enrollment was the largest challenge in Hawai‘i, particularly at the smaller community colleges. Some funding was used early-on to support low enrolled courses—allowing courses to run with low enrollment. But this solution was not sustainable. While enrollment in the pre-engineering program grew as a whole, in large part due to the introduction of the new ASNS degree, enrollment in certain courses remained low.

An analysis of low-enrolled courses revealed that a number of factors contributed to the problem:

1. The mere threat or suggestion that courses might be cancelled drove potential pre-engineering students to other options at other larger community colleges or to the mainstream institution where the threat did not exist.
2. Having three different sets of pre-engineering core courses for civil, electrical, and mechanical engineering majors might be an asset at mainstream institutions, but it only diluted enrollment at small colleges and created unnecessary competition between courses.
3. If one course in a required sequence of courses was cancelled due to low enrollment, students could not remain on a timely pathway to transfer and degree completion.

An important step toward solving the low enrollment barrier came directly from co-joining curriculum committees of the community colleges and the mainstream institutions in the short term. The Dean of the COE at UH-M invited the Kapi‘olani Community College STEM Director to work closely with the curriculum committee to identify the most vital courses for pre-engineering and challenged the COE faculty from different departments to identify a common core curriculum that prepared students for engineering. A common core, rather than three different core courses, identified the essential courses that should be taught at the community colleges to satisfy the entrance requirements at the UH-M. For example, the curriculum committee agreed that students in pre-engineering should know how to write a computer program. The mechanical engineering majors required Fortran programming, the electrical engineering required C++ or Java script. Civil engineering would accept any of the programming classes. The curriculum committee soon realized that by requiring different programming languages for different majors meant that the UH community colleges had to teach all of the programming course options, and this divergence meant that they would all be low enrolled. By asking the committee to identify a common programming course that would satisfy the programming requirements at the UH-M, this problem was eliminated. The mainstream universities often do not recognize the challenges faced by small colleges. By simply providing input in the committee and working together to find a common pre-engineering core of courses, the low enrollment issue was diminished and ultimately overcome.

Armando Hernandez and Daniel Johns, PEEC interns from South Dakota State University, in 2012 collecting water samples from the White River on Pine Ridge Reservation in South Dakota. Samples were tested for heavy metals concentrations including As, Ba, Pb, Se, and U. Uranium is of particular interest to the community because of uranium extraction mines in the locale. (Photo credit: Joanita Kant)

11.

Assembling interconnected networks for advancement in engineering: Champions and community

G. Padmanabhan (ND), Hannan LaGarry (SD), Robert Franco (HI), Lane Azure (ND), Lori Alfson (ND), and Carol Davis (ND)

INTRODUCTION

This chapter looks at the importance of champions and community in successful collaborations and what made those alliances work. PEEC attracted champions within Native Hawaiian (NH) community colleges and tribal colleges, mainstream universities, and their surrounding communities. Such champions provided local engineering expertise and projects with which PEEC could collaborate.

THE HAWAIʻI EXPERIENCE

The Hawaiʻi Pre-Engineering Education Collaborative (PEEC) (2010-15) was developed with NSF funding and leadership from Kapiʻolani Community College (KCC) and partnerships with four other community colleges, Honolulu, Leeward, Windward, and Maui in conjunction with UH-at Mānoa.

Hawaiʻi's PEEC leadership team

- ***Kapiʻolani Community College, Honolulu, HI:*** Louise Pagotto, Keolani Noa, Maria Bautista, Hervé Collin, Aurora Kagawa-Viviani, Leon Richards, Robert Franco, and Jeffery Arbuckle
- ***University of Hawaiʻi at Mānoa:*** Peter Crouch, Joshua Kaakua, and Mehrdad Nejhad
- ***University of Hawaiʻi Maui College:*** Mark Hoffman
- ***Windward Community College:*** Heather Stroupe, Floyd McCoy, Douglas Dykstra, Ardis Eschenberg, "Woody" Sydney Garrison, Joseph "Joe" Ciotti, and Alex Parisky
- ***Leeward Community College:*** Hannah Aldridge, Mike Pecsok, and Ron Flegal

- ***Honolulu Community College:*** Kerry Tanimoto, Erika Lacro, Tasha Kawamata-Ryan, and Norman Takeya
- ***University of Hawaiʻi System:*** John Rand, Joanne Itano, and Suzette Robinson

Louise Pagotto, then Vice Chancellor for Academic Affairs at Kapiʻolani Community College (KCC), and now Interim Chancellor, served as PI on the PEEC grant and coordinated program development discussions across the six participating campuses. Robert Franco, who is a national leader and an advocate for developing higher educational opportunities for Native Hawaiians (NHs), Samoans, and other under-represented groups, composed both the initial letter of intent to participate in the NSF PEEC, and the full grant proposal. John Rand, then Kapiʻolani STEM program coordinator and now Director of the University of Hawaiʻi (UH) STEM Education Office; Maria Bautista, then Chair of the Math/Science Department and now Kapiʻolani STEM Program Director; and Hervé Collin, Kapiʻolani STEM professor and Associate in Science in Natural Science (ASNS) degree program coordinator, played lead roles in bringing together Kapi’olani and the UH-M College of Engineering faculty to map out the pre-engineering concentration within the ASNS degree as a two-year to four-year transfer pathway. Peter Crouch, Dean of the University of Hawaiʻi at Mānoa College of Engineering (UH-M COE), and Joshua Kaakua, then Director of the Native Hawaiian Science and Engineering Mentorship Program and now Program Coordinator at the UH STEM Education Office, played lead roles in directing UH faculty collaboration.

The PEEC grant sought to increase educational access and success for NH students in engineering fields. Hawaiʻi’s PEEC project enabled its community colleges to transfer more well-trained NH students to the UH-M COE, where NHs are significantly underrepresented in the total graduate pool.
The broader context for the PEEC project was expressed by the then UH Vice-President for Academic Planning and Policy, Linda Johnsrud, as follows:

> *Our island state is caught in a confluence of resource shortages, insufficient local engineering talent, and the rapid deterioration of our island ecosystem and infrastructure. The new UH Strategic Plan for 2008-2015 recognizes the urgency of ecological and economic challenges confronting the State of Hawaiʻi and places special emphasis on the role of Native Hawaiian students and communities in overcoming [shortages] . . . .* (after UH, 2010)

Hawai‘i loses a considerable portion of its educational investment when young engineers are recruited to mainland positions. The UH System emphasis on increasing engineering and STEM degree completion by NH students is driven by the understanding that NH students have strong ties and commitments to their Native families, homes, lands, and communities. The hope is that these commitments can outweigh salary differentials in location decision making and that they will remain in Hawai‘i.

With an NSF grant entitled, “Innovation through Institutional Integration (I-cubed),” KCC researched the process of institutionalizing NSF funding and developed the framing concept of the “Kapi‘olani STEM Enterprise.” This “Enterprise” included partnerships with six feeder high schools, many of which had between 150 and 250 NH students enrolled. At the end of the STEM transfer pathways were two four year institutions, UH at Mānoa and UH-Hilo, with whom KCC also partnered on Hawai‘i Experimental Programs to Stimulate Competitive Research (EPSCoR) and All Nations Louis Stokes Alliance for Minority Participation (ANLSAMP) programs.

As part of the collaboration with Hawai‘i EPSCoR, KCC received EPSCoR workshop funding to develop “strategic synergies” between EPSCoR state programs and Campus Compact offices in Oklahoma, Montana, Kentucky, Tennessee, New Hampshire, and Maine. In Hawai‘i, HI EPSCoR funding supported STEM outreach and enrichment to Palolo Public housing, where more than 85 percent of the residents are Native Hawaiian, Samoan, or Micronesian. In Oklahoma, Montana, and Maine, concerted efforts at improved STEM outreach to NH communities were developed.

The KCC work with Campus Compact, the Carnegie Foundation, and the UH has resulted in a large number of sustained partnerships with private, public, and non-profit organizations, such as Palolo Public Housing; the Palolo educational pipeline through elementary, middle, and high schools; and numerous environment-serving organizations, many of which engage the wisdom of Native Hawaiian cultural practitioners.

Many representatives of these private sector businesses attend KCC’s annual STEM Undergraduate Research Fair (SURF) and provide critical review of student research posters, and they encourage Native Hawaiian students to pursue employment opportunities at businesses. In general, these businesses provide paid internship opportunities for undergraduate students advancing through the UH College of Engineering, but, results in Hawai‘i indicate that college students especially benefit from getting a personal introduction to related business career opportunities.

Following KCC's lead, all other UH PEEC campuses developed similar collaborations with private sector businesses in their locales and statewide. The challenge ahead is to further develop "collaborations" into authentic "partnerships." These alliances should include clear roles, responsibilities, communication channels, and identify mutually beneficial goals and outcomes. In addition, there should be estimated time periods for establishing the partnerships and related tasks, along with sharing of critical resources between the PEEC programs, campuses, and collaborations between public and private sector organizations.

BACKGROUND OF TRIBAL COLLEGES

Some of the key missions of tribally controlled community colleges envisioned by many Native American (NA) leaders during the 1970's focused on economic development, educating students for a first job in local or regional businesses, and increased local community control (Oppelt, 1990; Stein, 1992; & Wheeler, 2004). The shared vision of the American Indian Higher Education Consortium (AIHEC) for tribal colleges included five characteristics: 1) located on a reservation or near populations of NA people, 2) controlled by administrators and faculty, a majority being NA, 3) enrolled a majority of NA students, 4) NA culturally-derived curriculum, appropriate for the NA population served, and 5) based on learning methods and experiences that are informative of NA culture (Stein, 1990 & Wheeler, 2004).

Tribal colleges and universities are expressions of hope. The community, for whom and by whom such schools have been created, has continued expectations for improved conditions, greater self-awareness, and cultural renewal and growth (Wheeler, 2004). Tribal colleges, by their very design, are expected to maintain a harmonious and mutually beneficial relationship with the community on the reservations where they are situated.

Champions are possibly the most influential factor in any movement. They may be visionaries who are tenacious, passionate, and perseverant about their cause. Lynch (1999) noted that without at least one accomplished champion, the chance of successfully sustaining, nurturing, and transforming a cause is almost nil. That has been the case within NA education as well. Many champions in the community have contributed to the success of the tribal college movement through their dedicated and passionate work. Recently, for example, the South Dakota (SD) PEEC concluded that the most sustainable program projects were those with champions inside a local tribal or community agency (Kant et al., 2014; and Tinant et al., 2014).

In the early years, tribal college leadership was focused on identifying resources that enabled them to establish basic academic programs. Once the Indian Community College Act was funded and tribal colleges were able to acquire accreditation, tribal colleges began to expand their academic offerings. Those colleges were fortunate to attract some dynamic education leaders in the early years, leaders who were enrolled members of their tribes. Some of the champions who helped to shape the formative years of the tribal college movement were: Joe McDonald, President of Salish Kootenai College in Montana; Gerald “Carty” Monette, President, Turtle Mountain Community College in North Dakota (ND); Tom Shortbull, President, Oglala Lakota College in SD; Lionel Bourdeaux, President, Sinte Gleska University in SD; Jim Shanley, President, Fort Peck Community College in Montana; Richard Little Bear, Chief Dull Knife College in Montana; and S. [Sister] Verna Fowler, founding President of the College of Menominee Nation (1992-2016), one of the longest-serving TCU presidents.

There were other tribal college presidents, but the above individuals were in leadership roles at tribal colleges in those years, and they were particularly instrumental in gaining major opportunities that impacted the future of all. In addition to the presidents, others made major contributions in those start-up years. The first President of the American Indian Higher Education Consortium (AIHEC) was David Gipp, a Standing Rock (SD) enrollee. Among his staff, were leaders such as Bodine Stuart (Three Affiliated Tribes), Perry Horse (Kiowa), and Richard Nicholes (Pueblo). Those involved in the early years would definitely credit Jack Bardin, on the faculty at Sitting Bull College, as one of the key players in the movement. His untiring work with legislation, accreditation, and relationship-building for the tribal colleges was a major factor in their success. Tribal college board members included Stanley Real Bird from Rosebud, SD, and the group’s spiritual advisor, who accompanied Bourdeaux to meetings along with Resa Davis of Turtle Mountain Community College (TMCC). Davis was named to the first Board of Trustees at TMCC and remains in that position today. She was a well-known advocate for the movement and spent many days in Washington, DC, advocating for tribal colleges. Gerald One Feather and Birgil Kills Straight of Oglala Lakota College (OLC) were very active in the early days and made major contributions to their own colleges as well as to the overall effort. Another active leader was Paul Boyer, founder of the Tribal College Journal (TCJ) and chronicler of the all-PEEC conferences (Boyer, n. d., ca. 2012 and n.d., ca. 2014). This journal continues to chronicle the future for tribes through higher education. The TCJ helps to explain the role of tribal colleges to those who want to know more.

The tribal colleges would not have had STEM success without the continued support from NSF's Lura "Jody" Chase, Director of the Tribal Colleges and Universities Program (TCUP).   She was the director of the Rural Systemic Initiative that represented the first substantial effort by NSF to support tribal colleges. Out of this program came two important NSF initiatives, TCUP responsible for expanding STEM programs at tribal colleges and the current PEEC program, primarily expanding engineering programs.

One cannot forget the historical leaders of tribes who were there when tribes lost much of their land and way of life. For example, Cheyenne Chief Dull Knife in the 1800's told his people,

> *We can no longer live the way we used to. We cannot move around anymore the way we were brought up. We have to learn a new way of life. Let us ask for schools to be built in our country so our children can go to these schools and learn this new way of life* (Chief Dull Knife College, 2016).

THE NORTH DAKOTA EXPERIENCE

North Dakota PEEC leadership team

- ***Cankdeska Cikana Community College (CCCC),*** Fort Totten, ND: Leander McDonald, Lane Azure, Mike Parker, and Karl Haefner
- ***Nueta Hidatsa Sahnish College (NHSC),*** New Town, ND: Clarice Baker-Big Back, Lori Alfson, and Stacey Mortenson
- ***Sitting Bull College (SBC),*** Fort Yates, ND: Koreen Ressler, Gary Halvorson and Joshua Mattes
- ***Turtle Mountain Community College (TMCC),*** Belcourt, ND: Kelley Hall, Larry Henry, and Ann Vallie
- ***North Dakota State University (NDSU),*** Fargo, ND: Robert Pieri and G. Padmanabhan

North Dakota's PEEC program is a joint venture among four tribal colleges and one mainstream university. The grant proposal was submitted by the following tribal colleges: Cankdeska Cikana Community College (CCCC) in partnership with Nueta Hidatsa Sahnish College (NHSC), Sitting Bull College (SBC), Turtle Mountain Community College (TMCC); and a collaborating non-tribal mainstream institution, North Dakota State University (NDSU). Each of the community colleges is on a reservation: CCCC, Spirit Lake Reservation; NHSC, Fort Berthold Reservation; SBC, Standing Rock Reservation; and TMCC, Turtle Mountain Band of Chippewa Reservation.

All of the participating colleges are relatively far apart. Under the ND PEEC program, each tribal college and NDSU had separate budgets and was independently managed. At NDSU, the program was housed in the Mechanical Engineering, and Civil Engineering Departments in the College of Engineering. The PIs were administrators for all except SBC and NDSU. Each college has a strong relationship with the tribal community on respective reservations.

The ND PEEC collaboration is the culmination of more than 18 years of active engagement in STEM education on the reservations by NDSU engineering faculty led by G. Padmanabhan and Robert Pieri, including a year-long academic sabbatical by Pieri at TMCC. Carol Davis (TMCC), G. Padmanabhan, (NDSU), Robert Pieri (NDSU), Wei Lin (NDSU), Floyd Patterson (NDSU), Sharon Cobb (NDSU), Laurel Vermillion (SBC), Lizz Demaray (NHSC, formerly FBCC), and Eric Longie (CCCC), were some of the champions who were involved in the early stages of this collaborative effort (Davis et al., 2000). Over the years, several other faculty from the tribal colleges and NDSU have participated in this continuing collaboration to sustain, nurture, and advance STEM education in tribal colleges. The activities and student projects were always community-relevant and culturally supportive (LaVallie, 2013 and 2014). During Pieri's sabbatical, the champions for the cause of bringing engineering education to reservations from tribal colleges and NDSU came together with vigor and dedication to develop the ND PEEC.

The ND PEEC supported a tribal college vision of expanded life-choices for reservation residents that could provide more technical competency for tribal decision-making, infrastructure improvement, and the opportunity for personal and tribal advancement without loss of cultural heritage. Some of the incidental benefits to NDSU are expanded participation of culturally diverse students and shared fulfillment of the NDSU1862/1994 land grant mission. Others include improved faculty-student communication and interaction, as well as the expansion of the talent pool entering STEM professions. The project is student-centered and cohort-based and was designed to apply the pedagogies of experiential and service learning within the local community whenever possible. Leaders crafted a culturally-adaptive environment with rigorous standards. They established content and cultural advisory boards with membership from participating colleges.

The heart of the project is the interaction of tribal college, mainstream university, and engineering professionals, to facilitate the recruitment, education, and support of tribal students to acquire and hone the skills that will allow them to enter the engineering profession or contribute in some other fashion to their communities and the nation. The project accomplished this vision by impacting students through interactions with faculty/ staff, curriculum, and supporting functions/agencies, in a culturally supportive fashion (Pieri, et al., 2013ab).

Interaction with community partners in North Dakota

Cankdeska Cikana Community College

In 2009, Cankdeska Cikana Community College (CCCC) convened a group of community members, tribal leaders, and college faculty and staff to help establish the needs of the community. The group used Nominal Group Technique (NGT) to prioritize the needs. They established the need to develop a pre-engineering program that would benefit the community, the college, and surrounding reservation businesses. In September 2010, NSF announced the ND PEEC award, and CCCC was named as the tribal college to lead the collaboration. Leander “Russ” McDonald was the Vice-President of Academic Affairs for CCCC and the project Principal Investigator (PI) as lead tribal college partner. The ND PEEC was submitted to the NSF as the 2 + 2 + 2 + ∞: Pipeline for Tribal Pre-Engineering to Society (PTiPS). The milieu for the project was two years of tribal community college, two years of a university level engineering program, with two more years of Master’s level engineering, followed by an infinite amount of learning and collaborating from the tribal engineering student.

The leaders of the PTiPS determined the next steps in an action plan that would help them to meet the goals and objectives of the NSF grant. In October 2010, Clarice Baker-Big Back (NHSC), Bob Woodle (NHSC), Leander McDonald (CCCC), Koreen Ressler (SBC), Larry Henry (TMCC), Ann Vallie (TMCC), Robert Pieri (NDSU), special guest and retired TMCC president Carty Monette, and Lane Azure (CCCC) convened to conduct a Nominal Group Technique (NGT) for the collaboration. There were 42 items generated by the group. During the data reduction step, all but eleven items remained. Sharing resources, faculty recruitment, community support, and curriculum development were among the top prioritized items from the group. The group continued to meet on a regular basis, but they were tasked with finding their autonomy in the program. The need for a curriculum that would satisfy the needs of each of the communities was eminent. McDonald believed it to be a priority to follow through from the PTiPS NGT results and develop specific needs from the company that could potentially employ the graduates of the PTiPS collaborative. Sioux Manufacturing Corporation (SMC) started as a joint venture between the Spirit Lake Nation (formerly the Devils Lake Sioux Tribe) and the Brunswick Corporation. The

SMC, that devoted much of its production to making Kevlar products, was created to provide employment opportunities for the members of the tribe, since the company employs eight engineers.

The question to ask the company of engineers and the human resource director was: What topics do you feel are necessary in a pre-engineering program that will impact this community?” The typical group of 10 to 18 participants could potentially generate 40 or 50 items that would be reduced to four or five. During the community needs assessment conducted in 2009, over 100 items were generated. However, these engineers were quick to establish a group of items that were necessities for a new pre-engineering program. As a group, the SMC employees were well-informed about the topic of the pre-engineering program. The ideas contributed by each participant were kept concise and succinct in line with the NGT process used for the meeting. Among the top 10 items, introduction to engineering and a computer aided design course led the prioritized items as the most important to the group.

It soon became apparent that the Chief Analytics Officers (CAOs) for each of the tribal colleges were finding it difficult to find the time to devote to the PTiPS project and, at the same time, operate the academic departments for each of their respective colleges. Each of the tribal colleges was to recruit and to hire an engineer capable of teaching university level engineering courses to each of their respective students. These engineers would also provide much of the heavy lifting for each of their respective colleges. Larry Henry, Dean of Academics for TMCC, had hired the first engineer for the PTiPS project -- new graduate from NDSU, Ann Vallie had earned her BS in electrical engineering. Soon after, the director of the PTiPS project at CCCC, Lane Azure, recruited computer engineer Timothy Legg. Vallie was instrumental in collaborating with Azure and Pieri to develop the starting curriculum for the PTiPS pre-engineering program. Time was running out for each of the colleges, since it was imperative to begin to deliver the curriculum, in order to meet the need to graduate students from the program so that they could matriculate to a university level engineering program.

The partnership with the North Dakota University System (NDUS) for each of the tribal colleges was connected through common core numbering and articulation agreements with the eleven colleges and universities within the NDUS. If the tribal college had provided the NDUS with a copy of their curriculum and syllabi, their courses would be listed on the NDUS website, Silver Certificate. The certificate was a road map for each of the colleges to determine how a course would articulate from one institution to another. In addition, the NDUS has an Interactive Video Network (IVN) that allows the colleges to interact with one another. Initially, this system was used to allow students to take courses from one institution, even if they were enrolled in another. The tribal colleges were connected to this system due to their size. Not having an instructor to teach a specific course was no longer a problem for tribal colleges, since they could connect to the IVN and pick and choose courses to add to their semester schedule as they saw fit. At one point, the tribal colleges began to build capacity with their instructional needs, and the IVN lost its luster. However, with the new PTiPS project, delivering a college engineering course at all sites simultaneously or by four different instructors was not feasible. Therefore, the IVN became popular again, since it allowed for NDSU to offer an “Introduction to the Engineering Profession” course to all of the tribal partners. In addition, having a mathematics instructor teach a third semester calculus course to one student at a partner site was not cost effective, but having that same instructor offer the same course to three other sites made perfectly good sense, and it now turned a course with only one or two students, into a course with six to ten students enrolled.

The PTiPS PEEC project was a community of champions. The partnership set aside bureaucracies and top-down leadership styles and utilized proven methods to help determine the needs of each of the communities. All in all, a well-established program emerged and was delivered by the founders and engineers of the project.

Nueta Hidatsa Sahnish College (NHSC)

The North Dakota PEEC collaboration partnered with local industries and tribes to provide site tours and paid summer internships for students. Community industries with which NHSC partnered to provide site tours for students, included Enbridge Pipelines, Verendrye Electric, Sioux Manufacturing, and Northrup Grumman. These site tours give students the “big picture” of Engineering, showing students what engineers do in the real world. Many times there is a lack of connection between what students are learning in the classroom, and what engineers do in the profession. It is often difficult for students to make connections without actually seeing their studies executed in the real world. Students can see in real-time how the mathematics and science are applied, as they learn. In addition, students make connections with local industry leaders and engineers, who can serve as mentors or play an important part in their job search when they graduate. Local industries and agencies also provided paid summer engineering internships to NHSC students. Students have worked with Renaissance Engineering & Testing on local road construction projects; with local manufacturing firms Northrup Grumman and Sioux Manufacturing; and also with the tribal government and tribal engineers on environmental, road, and waterway projects.

THE SOUTH DAKOTA EXPERIENCE

South Dakota PEEC leadership team

- ***Oglala Lakota College:*** Gerald Giraud, C. Jason Tinant, Hannan LaGarry, James Sanovia, Tawa Ducheneaux, Alessandra Higa
- ***South Dakota School of Mines and Technology:*** J. Foster Sawyer, M. R. Hansen, Damon Fick, Jennifer Benning, Dan Dolan, Scott Kenner
- ***South Dakota State University:*** Bruce Berdanier, Suzette Burckhard, Kyungnan Min, Richard Meyers, and Joanita Kant

South Dakota's PEEC program is led by Oglala Lakota College (OLC) in partnership with South Dakota State University (SDSU), and South Dakota School of Mines & Technology (SDSMT). The OLC is chartered by the Oglala Sioux Tribe (OST), and consists of eleven teaching campuses and the *Piya Wiconi* administrative campus near Kyle, South Dakota (SD). Nine of the teaching campuses ("College Centers") and the *Piya Wiconi* campus are on the Pine Ridge Reservation, with the remaining teaching campuses in Rapid City, SD (non-reservation), and in Eagle Butte, SD, on the Cheyenne River Reservation. In addition to deliberately shifting the burden of travel from students to faculty, this decentralized system of widely dispersed college centers creates an expanded sense of what constitutes "community" for OLC. However, the program's emphasis has always been on activities and stakeholders within the Pine Ridge Reservation, consisting of Oglala Lakota County and the southern half of Jackson County, in addition to some trust lands in neighboring Bennett County. The South Dakota PEEC program at OLC is housed in, managed by, and conducted by their Mathematics, Science, and Technology (MST) Department.

Tribal priorities

Prior to receiving certain awards, namely 2009 NSF TCUP Phase III and 2010 NSF PEEC, the OLC MST Department had maintained close collaborations with Oglala Sioux Tribe (OST) agencies, but participation was limited to OLC MST Department faculty and staff. In keeping with their departmental aspirations to focus efforts on undergraduate research and service learning, one of the PEEC program's goals was to broaden and deepen tribal agency collaborations to include student researchers in co-curricular projects that addressed reservation needs. By the second year of the project, the SD PEEC identified additional stakeholders and collaborators. By the third year, the SD PEEC had well-established collaborations with tribal agencies, and they attracted more collaborating community organizations, Federal agencies, and academic collaborators.

In order to prioritize the needs of OLC's community partners, SD PEEC participants and community stakeholders gathered together for a "listening session" at a tribal Elder's residence often used by locals as a meeting place. This event lasted several days, and meals were provided. Most reservation-based partners and stakeholders were present, as were the SD PEEC leadership team, PEEC-engaged graduate and undergraduate students, and interested community members. In this way, the group followed culturally appropriate protocols, including the need for consensus and introductions. This series of meetings was the pinnacle of the SD PEEC's many interactions with their community partners.

South Dakota PEEC's community partners

The SD roster of tribal government, community, and academic partners, is longer than could be listed in this chapter, but some examples are listed below. The SD PEEC stakeholders and partners are diverse and widely dispersed across the state, particularly in western SD. That is to be expected since the campuses of OLC and SDSMT are in extreme western SD, while SDSU is along the eastern border of the state.

Those stakeholders and partners listed below were directly engaged in PEEC-driven student research or experiential learning (often a hybridized form of service learning), as described by Kant and others (2014), where authors reported lessons learned, including successes, best practices, challenges, hopes for the future, and two case studies (pp. 468-469). Under best practices, they also reported that identifying champions is crucial to success in PEEC as follows:

> *We conducted an informal survey of the tribal governmental agencies with an engineering interest near the beginning of our program. The only sustainable program projects were those with … PEEC champions inside the community agency* (Kant, et al., 2014, p. 468).

Tribal government

Very early in the SD PEEC program, leaders met with various offices within the tribal government, including the President's and Fifth Member's offices, to introduce themselves and to explain details of the PEEC project and its goals. At the time, PEEC leaders were introduced to the appropriate

Elders, who continued to guide and to advise in the coming years. Since the inception of the PEEC program, there have been three OLC administrations in office, and the SD PEEC has continued to have the support of tribal government in fulfilling the PEEC program's goals and objectives.

Tribal Council. In 2012, PEEC leadership was invited by Defenders of the Black Hills to co-present to the Oglala Sioux Tribal Council, a summary of the SD PEEC's goals and objectives, along with PEEC student research in the area of heavy metals concentrations on and near the Pine Ridge Reservation. This presentation was open to the public and was very well attended by community members. Following the presentations, the Tribal Council passed a resolution in support of PEEC's ongoing collaborations with tribal agencies.

Land Office. The SD PEEC's collaborations with the OST Land Office began in 2011 and increased in 2015, largely based on ongoing student research in heavy metals. The Land Office hopes to obtain accurate measurements of the levels of exposure to ionizing radiation and radon gas for residents of the reservation.

Natural Resources Regulatory Agency (NRRA). The NRRA was the SD PEEC's first collaborator among the OST tribal agencies, and was consulted frequently during the development and writing of the initial grant proposal. The PEEC's partnering with NRRA is mainly the result of ongoing student research in the area of heavy metals concentrations, including plants and soil, but especially in groundwater. The NRRA was consulted in depth as the Oglala Sioux Tribe was preparing contentions in its interventions against ongoing *in situ* leach (ISL) uranium mining near Crawford, Nebraska (2008), and proposed ISL uranium mining near Edgemont, SD (2010). These interventions would eventually lead to hearings before the Atomic Safety and Licensing Board, and bring together many community partners to serve as cultural or scientific experts to testify on behalf of the OST. These interventions continue to this day, with the next one scheduled for August 2017.

Environmental Protection Program (EPP). The SD PEEC's partnering with the tribe's EPP are primarily focused on water quality, particularly in the area of surface water. One of the most long-term team projects, involving many students from several universities and academic disciplines within OLC, includes the use of aquatic invertebrate larvae to assay stream health and exposure to toxic contaminants. This project is ongoing, and has amassed large amounts of useful data on the chemistry, biological diversity, and flow dynamics of Pine Ridge Reservation's rivers and streams. Through this program, detailed longitudinal data of stream flows is being compiled and analyzed.

Cultural Affairs and Historical Preservation Office (CAHPO). The SD PEEC's joint projects with OST CAHPO extend beyond the PEEC program into several other areas of research and culturally-based service learning. However, the PEEC-related collaborations are largely the result of ongoing student research into heavy metals concentrations. While not of direct concern to the CAHPO, many areas of concern also have historical and cultural sites within their jurisdiction. As such, OLC faculty often worked together, as experts, to testify before the Atomic Safety and Licensing Commission.

Community organizations

The OLC's service area, which includes the Pine Ridge Reservation and Rapid City (among others), is home to several tribal and non-tribal community organizations dedicated to the transmission and preservation of Lakota culture or the protection of Lakota Treaty Territories. Most of these had become collaborators prior to the start of the PEEC program, and they include Owe Aku, Defenders of the Black Hills (DBH), and the Northwest Nebraska Resource Council (NNRC). In subsequent years, OLC began similar collaborations with Dakota Rural Action (DRA) and the Alliance for Responsible Mining (ARM). All of those organizations were particularly interested in PEEC student and faculty research into anthropogenic and naturally-occurring concentrations of heavy metals on and near Pine Ridge Reservation.

Another community partner that was very productive in terms of PEEC student engagement included Thunder Valley Community Development Corporation described below.

Thunder Valley Community Development Corporation (CDC). Thunder Valley CDC is a development project operated by the people of the Pine Ridge Reservation as a model sustainable community offering affordable housing to local residents, and it is within fifteen miles of the OLC *Piya Wiconi* Administrative Campus. Thunder Valley as an organization was launched in 2010 as a Housing and Urban Development (HUD) Sustainable Communities grantee and was formally recognized by President Obama in 2012. The SD PEEC alliance with this group is largely the result of PEEC student service learning, research, and engineering design projects focused on sustainable housing and green energy. In the later years of the PEEC program, this alliance has grown to be the largest single engager of the program's students, and has inspired projects involving the design, construction, and internal environmental monitoring of energy efficient straw-bale houses and the design and construction of rocket mass heaters, solar panels, and wind turbines. This collaboration has included the Department of Applied Sciences at OLC and collaborators at the University of Colorado-Boulder. This alliance has also generated published work from South Dakota's PEEC program.

Academic collaborations in South Dakota

A primary objective of the South Dakota PEEC program is to co-instruct pre-engineering classes and co-mentor mixed groups of students (from OLC, SDSU, and SDSMT) in research and service-learning projects. The goal is to allow OLC's NA students to feel more confident within an intellectual and professional community of peers and mentors. After finishing an Associate's degree in pre-engineering at OLC, the hope was and is that OLC students would continue their educations at SDSU or SDSMT to complete a bachelor's degree. While the vast majority of OLC's students are Native, students from SDSU, SDSMT, and our other academic collaborators, included NA, non-Native (nN), and international students. Results indicate that OLC's students greatly benefitted from this approach, and they gained a sense of "belonging" to a broader academic community. That benefit has spread from the OLC PEEC participants to other OLC students in other programs.

The SD PEEC's academic collaborator in the area of sustainable housing is the University of Colorado (UC)-Boulder and the Native American Sustainable Housing Initiative (NASHI) in partnership with the Thunder Valley Community Development Corporation (CDC) and the OLC Department of Applied Sciences. This interdisciplinary service-learning project, launched in 2010 by Rob Pyatt, a UC instructor and research associate, is dedicated to helping solve the Pine Ridge Reservation's affordable housing shortage. About fifteen of UC's undergraduate students in their environmental design program have worked alongside the OLC MST Department's PEEC and Applied Sciences students to build sustainable prototype houses designed by students with community input for inclusion in the Thunder Valley model community.

The SD PEEC's academic collaborators in the area of heavy metals concentrations fall into three groups: those dealing with geology, water chemistry, and radiation measurement. PEEC's primary collaborator in the area of geology is Chadron State College (CSC), Chadron, NE. Since the inception of the PEEC program it maintained a summer research program focused on mapping geological strata and structures in southern Oglala Lakota County on the Pine Ridge Reservation. This project included undergraduate and graduate students from OLC, SDSMT, SDSU, and CSC working together to map the White Clay Fault. To date, it is the only known geological structure that is also a transmitter of heavy metals.

In the area of water chemistry, the SD PEEC has had several academic collaborations. They worked with the University of Wisconsin-Whitewater and the Technische Universität Darmstadt to sample and test the Pine Ridge Reservation's surface and groundwater for heavy metals. They also worked with the University of Illinois Urbana-Champaign's Center of Advanced Materials for Purification of Water with Systems, and with the Technische Universität Darmstadt engineer (thanks to the Lakota Village Fund) and tested innovative methods and materials for filtering the Pine Ridge Reservation's municipal and residential water supplies. They hope to expand these efforts by working with Filters for Families to test, on the Pine Ridge Reservation, filtration systems that have been successful in Nepal and Bangladesh.

In the area of radiation detection in 2016, OLC re-energized a collaboration with the University of Michigan-Ann Arbor (UM) Department of Nuclear Engineering and Radiological Sciences that began in 2009, following tours of abandoned and as-yet un-reclaimed open-pit uranium mines in northwestern South Dakota. If successful, this collaboration, along with a new collaboration with the UM Consortium for Verification Technology, will directly measure radiation, potential radiological contamination, and radionuclide isotope ratios on the Pine Ridge Reservation using a variety of instrumentation that includes unmanned aerial and terrestrial vehicles.

South Dakota reflection

After reflecting on the success of the SD PEEC's interactions with and responses from their partners, reservation locals offer the following. First, their listening session with their partners and stakeholders was likely the most significant single event during the SD PEEC program. For the leaders and students of the SDSU and SDSMT programs, it was an opportunity to see and be seen, and to experience Oglala Lakota culture and decision making first hand. For the community partners, interested stakeholders, and community members in attendance, it was an opportunity to gauge the sincerity and commitment of the “outsiders.” Following the meeting, the “outsiders” were welcomed as newly discovered “insiders,” and with that moving forward, they were of one mind with one goal: improving the quality of life for all on the Pine Ridge Reservation. That step forward was immeasurably helpful to the success of the SD PEEC program.

Second, before PEEC, there was little or no pent up demand for engineering on Pine Ridge Reservation, but there are a wide variety of needs, challenges, and opportunities for PEEC students, faculty, community partners, and academic partners to address. While many of these needs, challenges, and opportunities could be addressed using standard engineering practices and training, many needs were not addressed in the past, and solutions would have required creative thought and novel approaches in order to reach resolution. This benefitted the SD PEEC program by drawing our engineers and scientists together into teams to work towards common goals of interest to both groups. It also required their engineering students to focus on the service learning aspects of their interactions with the reservation community-- quite different from the classroom experience of class discussion, homework, and exams. These experiences were formative for the SD PEEC and resulted is lasting personal and professional bonds between them, including both reservation insiders and outsiders. This was the sense of greater community to which they aspired.

Third, despite the success of the SD PEEC program goals as proposed to NSF, and in addition to the personal and professional success of the students who participated, engaging community partners underscored the unmet needs and challenges still faced by the Pine Ridge Reservation every day. The SD PEEC participants did their best with the expertise and resources they had, but much of what they learned from their community partners will need consistent work over generations. It is the hope of SD PEEC leaders that their student PEEC participants will use their new expertise to carry on the work that needs to be done, building on and strengthening the bonds and commitments they made during the five-plus years of the PEEC program in SD.

THE WISCONSIN EXPERIENCE

Wisconsin PEEC leadership team

- ***College of Menominee Nation (CMN)***: Sr. Verna Fowler, Diana Morris, Lisa Bosman, Chad Waukechon, and Holly Young Bear Tibbets

- ***University of Wisconsin-Madison, WI:*** Manuela Romero, Dante Frata, and Brian Nunez
- ***University of Wisconsin- Platteville, WI**:* David Kunz, Tammy Salmon-Stevens, Phillip Sealy, Bob Stuewer, and Cody Martin

S. Verna Fowler (President of CMN), Diana Morris (Chief Academic Officer), Holly Youngbear Tibbets (Dean of External Relations), and Lisa Bosman (Engineering faculty) are some of the champions responsible for bringing engineering to CMN. Although some non-engineering projects were implemented earlier by Lisa Bosman, typically, the collaborative project ideas were initially presented to the mainstream universities by the CMN administrators. Faculty members were subsequently brought into play.

Community engagement was almost non-existent. Although the Tribal Council is not involved in CMN governance, the Curriculum Committee of the Council has one community representative on the committee. Service learning projects have not been employed to improve community interaction at this stage in the Wisconsin PEEC. Students have worked collaboratively with students from other colleges. Some have worked in national laboratories.

CONCLUSIONS

Tribal colleges have enjoyed strong leadership over the years. Many such leaders devoted most of their professional lives to the tribal college movement that began more than 40 years ago. Their commitment was crucial to the success of the colleges. The community education champions believed in the people they served, and they led with integrity. Because tribal colleges often lacked resources in the early years, many leaders and champions of the cause worked for very little salary. In fact, when Turtle Mountain Community College (TMCC) in North Dakota was in its infancy, Gerald “Carty” Monette worked for three months without salary. This was not uncommon. Tribal college champions believed that tribal colleges were the key to the future of their tribes, and they were willing to make the sacrifice. They also knew that they had to put together the best academic teams they could find in order to meet accreditation standards and the needs of the communities they served. Many faculty members worked with very low compensation for the same reason the college presidents did. They believed in the students and the communities they served.

In the beginning, most of the tribal colleges offered standard two-year STEM courses that were geared primarily to meet the Associate of Arts and

Associate of Science requirements. As the colleges grew, so did the need to expand STEM offerings. Collaborations with university partners arose, enabling expansion that was facilitated through funding from NSF. Eventually tribal colleges were participating in All Nations Louis Stokes Alliance for Minority Participation Programs (ANLSAMP) and in PEEC, both intended to increase participation in engineering programs. Tribal colleges were moving beyond general STEM courses to more advanced areas and providing STEM professionals for reservations and surrounding communities and agencies. At the base of all of the success were committed champions for academic leadership on the reservations. Especially when those education champions joined with locals who championed a specific project on reservations, they created powerful synergies that advanced PEEC students.

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Cankdeska Cikana Community College students working on a laboratory project. (Photo Credit: ND PEEC).

12.

Increasing enrollment and graduation through teaching and learning strategies: Experiential learning

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WHAT IS EXPERIENTIAL LEARNING?

Experiential learning is the process of acquiring knowledge primarily through hands-on experiences as opposed to knowledge transfer from a content expert through lectures, presentations, and textbooks (Beard, 2010). More specifically, experiential learning can be described as, "learning through reflection on doing" (Felicia, 2011), the grasping of general principles, development of an attitude toward inquiry, guessing and hunches, and the possibility of solving problems on one's own (Bruner, 1960).

Experiential learning theory evolved from the constructivist theories of Kant, Dewey, Piaget, Vygotsky, and Kuhn (Kivinen & Ristelä, 2003). A central tenant of constructivism is that learners construct their own knowledge structures. Therefore, hands-on learning experiences are a platform for enhancing conceptual understanding (Ma & Nickerson, 2006). Vygotsky noted that "learning is a necessary and universal aspect of the process of developing culturally organized, specifically human psychological function" (1978, p. 90). Thus, incorporation of a learner's world view provides a basis for scaffolding new knowledge through Kolb's (1984) cycle of learning through experimentation, observation, reflection, and abstraction. Provision of time for "not doing" or a "white space" (Wankat, 2002) also allows learners to reflect on their experience.

Reflection opportunities can include formal practices such as journaling and informal opportunities such as shared meals, non-academic shared experiences such as hiking or games, or a pause in a lecture to provide learners an opportunity to organize their thoughts and explore new ideas.

Abstraction is the process of incorporating new observations into the learner's existing world view, and the result of shared experiential learning among a related group of learners is cultural evolution.

Experiential learning is central to all of the four Pre-Engineering Educational Collaboratives. However, since each of the collaboratives is located in diverse cultural and geographic settings, the application of experiential learning differs. For example, given the island nature and high population density of Hawaiʻi, experiential learning through the summer program is shaped around shared experiences including underwater robotics for coral reef restoration and "re-engineering" islands in the context of climate change and sea-level rise. The Wisconsin PEEC emphasizes that cohorts maintain strong cultural and community connections and reflection activities through shared meals and cultural activities. The South Dakota PEEC emphasizes working to identify and apply solutions to increase community resilience in the face of basic needs of reservation-sourced food and energy production and sustainable water use. The North Dakota PEEC focuses on providing students with open-ended learning experiences in both curricular and co-curricular spheres. Examples of Hawaiʻi, North Dakota, and South Dakota experiential learning activities are highlighted below.

EXPERIENTIAL LEARNING WITHIN PEEC

Hawaiʻi PEEC

As an island culture with limited resources, Hawaiʻi is uniquely positioned to offer experiential learning opportunities with local and global ramifications. As part of the PEEC program, Kapiʻolani Community College (KCC) developed a Service and Sustainability Learning Program that engages approximately 70 Native Hawaiian (NH) students per semester, involving them in high-impact projects within their STEM disciplines and steering them toward STEM careers in Hawaiʻi's workforce. The Hawaiʻi PEEC has attempted to weave life sciences and engineering into a more holistic approach in addressing major societal issues. Experiential learning projects have ranged from a global scope involving climate change and sea-level rise to local projects such as improving water efficiency in campus green houses. Students in the program also chartered a new local chapter of Engineers for a Sustainable World which developed a "rain garden" at KCC to better capture and utilize rainfall for a Native Hawaiian garden. Other STEM-related projects for Hawaiʻi's PEEC participants have included water quality monitoring in Maunalua Bay, engineering remotely operated vehicles to assess coral reef restoration efforts, and research on environmental dynamics and responses for Hawaiian ecosystems.

North Dakota PEEC

Experiential education is often perceived in terms of internships, and while that is a valuable component of experiential education, the North Dakota PEEC collaborative decided not to employ internships as the only experiential learning opportunity for students. Instead, leaders wove experiential education throughout all coursework and co-curricular activities. Integrating experiential education throughout the coursework helped students to see the “big picture” of engineering through experiences that were created both inside and outside the classroom. Non-traditional course/information delivery techniques that were used to infuse experiential learning into the curriculum included integration of real-world projects through project-based learning; providing non-classroom cultural experiences to promote collaboration, community, and culture; monthly industry field trips; and paid summer engineering internships.

Experiential education through project-based learning was a fundamental premise of the PEEC summer camps held at North Dakota State University (NDSU). Through this venue, students collaboratively worked on real-world engineering scenarios. As a team, students developed an engineering project plan and presented their findings to faculty in both written and oral form. Additional aspects of the Summer Camps included application of non-classroom cultural experiences, social gatherings centered on meals, integration of cultural elements such as opening and closing ceremonies, and incorporation of an equine leadership program as part of camp opportunities. Tools used for assessing experiential learning were traditional written reports, oral presentations, and videotaped discussions of scenario analyses (Chan, 2012 & Pieri, et al., 2013ab).

Monthly industrial field trips also were introduced into introductory engineering classes to give students a broader view of the engineering world. Industrial partners included Enbridge Energy Partners, Verendrye Electric Cooperative, Sioux Manufacturing Corporation, and NDSU. Visits to these companies and organizations allowed students to “experience” real world applications of mathematics and science, to build connections with potential employers, and to contemplate the question, “Where am I going?” from a better informed perspective.

Engineering internships remain an important component of experiential learning, and the North Dakota PEEC collaborative included course credits for engineering internships during summer months as part of the program. Tribal colleges in the collaboration, partnered with local industry to arrange paid student internships with assessments completed by supervisors as well as instructors. Significant positive outcomes from these internships included a “real world” perspective that the students gained, salaries that students earned for themselves, completed course credits that could be applied to their degree curricula, potential future job placement, and the opportunity to learn by doing.

South Dakota PEEC

Experiential learning through project-based service learning and undergraduate research experiences has served as the heart of the South Dakota (SD) PEEC program (Fick, et al., 2013; Kant, et al., Oct., 2014; Kant, et al., 2014; Sawyer, et al., 2014; and Tinant, et al., 2014). Although engineering courses were offered as part of the curriculum, it was the student research projects and co-curricular, community-focused activities during the summer programs that most strongly impacted and inspired student participants. As the SD PEEC program evolved, it became apparent that students were more highly interested and motivated by projects in which they could see a connection between their efforts and an outcome that clearly benefited the local community on issues of fundamental importance such as healthy, affordable food, and clean drinking water. Co-curricular activities in particular attracted more interest, built stronger bonds between students from different institutions, and inspired greater effort, teamwork, and commitment from the students, over other pursuits.

As the SD PEEC program progressed, it became evident that students in the program showed great respect, even reverence, for the land, water, air, and plants and animals in their environment. Therefore, projects in the SD PEEC evolved toward the food-water-energy nexus which incorporates many environmentally and culturally-related topics and which also meshed well with the expertise of the faculty involved in the program. Students were most attracted to projects in which there was a clearly identifiable problem such as a lack of fresh food choices on the reservation or a potential threat to water quality from upstream uranium mining activities. With these types of projects, students knew they were making a significant difference, and it gave them a common cause to work toward, strengthened their bonds as a cohort, and inspired them to go above and beyond the level of commitment and contribution shown for other projects.

Environmentally and culturally based co-curricular and student research projects also proved to be excellent catalysts for key elements related to Kolb’s (1984) experiential learning cycle including reflection, evaluation, and experimentation. Perhaps the best example of this within the SD PEEC is a sustainable greenhouse which was constructed in the town of Kyle, SD. Long drives (90 miles one way) through areas with little cell phone/ internet coverage promoted reflection and discussion among the students, allowing ideas to mature and develop into future action plans. Multiple engineering aspects of the greenhouse, such as construction materials, climate control, ventilation, water supply, and heating options provided ample room for experimentation. Faculty mentors also encouraged and supported experimentation in addition to participating in and nurturing reflection and evaluation of engineering and social aspects of the project. The co-curricular nature of the project was an extremely positive aspect, perhaps in part because the students were giving their time and energy of their own free will, rather than working on an assigned task. The co-curricular characteristics of the greenhouse project also encouraged participation from students from different universities, and the level of enthusiasm among the students was contagious. Everyone was welcome. There were many problems that needed to be solved. Thus, the need for the project was obvious, and it was fun to work together to address a serious community issue. These elements coalesced to create inspirational experiential learning for students and faculty alike, unparalleled in any classroom activity that was attempted in the SD PEEC program.

CONCLUSIONS

Experiential learning is a powerful method to create pathways for Native American students to pursue higher education in engineering which is the primary goal of the PEEC program. Linking experiential learning with projects that address basic human needs such as clean drinking water and the availability of healthy and culturally important food choices clearly illustrated to the students the benefits of employing engineering practices to positively impact local and global communities, and it was an effective method of stimulating enthusiastic participation among the students. Most of the PEEC programs incorporated some aspect of the food/water/energy nexus which touches all cultures and can be tailored to virtually any setting. Student participants recognize the importance of these fundamental needs, and addressing these needs imparts a sense of empowerment and the feeling of doing something right and good for their families, their communities, and the world around them. Addressing these issues in a co-curricular format elevates their efforts to an even higher plane where they are not only performing actions that benefit their communities, but they are doing them of their own free will because they know it is a good thing to do rather than because they were told, or assigned, to do them. Co-curricular projects also dissolved barriers between students (and faculty) and promoted additional learning through elements of Kolb’s learning cycle including experience, reflection, abstraction, and experimentation.

Experiential learning experiences in an engineering context also created a window into the realm of engineering and into the infinite possibilities that exist, both professionally and through academic research, to improve the world. Students not only become aware of the issues, but they become aware that they can actually do something about them. This sense of empowerment and recognition of their own abilities engenders attitudes of being capable of tackling formidable issues, of obtaining degrees in challenging STEM fields, and of achieving successful careers in science and engineering. Experiential learning is well-suited to breaking down perceived barriers in becoming engineers, and it has been a critical component in the success of the PEEC program in bringing Native American students into STEM curricula.

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The 2013 'IKE students at the Summer Engineering Experience 2 (SEE 2) program at the University of Hawai'i - Maui College. The SEE 2 students built and wired their own amplifiers. (Photo credit: Tasha Kawamata Ryan)

PART IV: Transforming institutional politics

13.

Transforming through institutionalization and replicability of PEEC

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INTRODUCTION

This chapter is about the process of institutionalizing practices and processes that were developed during the Pre-Engineering Education Collaborative (PEEC) project. Institutional theory holds that individuals and groups within an organization have intrinsic values, beliefs, and normative actions that define the way the world is and should be, and that these cultural values provide the underlying framework of an organization (Zucker, 1977). Thus, institutionalization of PEEC refers both to embedding processes that facilitate access to pre-engineering programs of study, as well as matriculation to, and success in, engineering programs through partnerships. It also engenders the value of Native engineers to solve problems facing Tribal Colleges and University Programs (TCUP)-serving communities and a more diverse engineering workforce across the nation as a whole. These processes and practices were integrated into unique TCUP campuses, but can be replicated across many higher education institutional types. The following are the experiences of PEECs in Hawaiʻi and South Dakota.

Hawaiʻi PEEC

The Hawaiʻi PEEC initiative, through NSF funding, brought together an alliance of four community colleges on the island of O'ahu: Honolulu, Kapiʻolani, Leeward, and Windward; and one on the island of Maui: Maui College. Their task was to train and to transfer a growing number of Native Hawaiian (NH) and other underrepresented pre-engineering students to the University of Hawaiʻi at Mānoa College of Engineering (UH-M COE).

Kapiʻolani Community College (KCC) was awarded an “Innovation through Institutional Integration” grant from the National Science Foundation (NSF) for 2009-2014. The title of this proposal was “Faculty Integration of Research and Education in Urban Polynesia” (FIRE-UP). This grant overlapped the funding period of the PEEC grant. The FIRE-UP grant supported comprehensive faculty development through campus-based summer institutes and participation in the Science Education for New Civic Engagements and Responsibilities (SENCER) Summer Institutes on the continent. The SENCER is a leading NSF initiative in undergraduate science education reform that supports the teaching of canonical science through capacious and contested civic issues. The SENCER website (2016) provides examples of “SENCERized” curriculum and teaching practices such as place- and project-based learning, service learning and undergraduate research.

The FIRE-UP grant also supported research through the KCC Office for Institutional Effectiveness (OFIE) on the process of institutionalizing STEM innovation. In 2009, OFIE administered to faculty, staff, and administration, the Assessment of Institutionalization Map (AIM) survey (Zhang Hill & Kirkpatrick, 2009).

In 2011, OFIE re-administered the same AIM survey to see what progress had been made in institutionalizing STEM innovations. Results indicated improvement in all six components of institutionalization measured by the survey as follows: Philosophy and Mission, Faculty and Staff Support and Involvement, Student Support and Involvement, Partnerships, Institutional Support, and Curriculum and Activities.

As the PEEC project progressed, OFIE continued to track STEM institutionalization at the KCC campus through close interaction with the PEEC Management Team. In terms of philosophy and mission, the new campus mission, vision, and values statements are available in both Hawaiian and English. This phrase includes the support and preparation of students for their productive futures in STEM careers in engineering; and physical, life, and computer sciences. It also recognizes that their futures involve rapid technological, cultural, and ecological transformations that represent major challenges and opportunities.

Faculty, staff, and student support for STEM institutionalization through PEEC innovations continued to grow as KCC developed new and successful innovation in undergraduate research in Hawaiʻi, on the continent, and internationally. Shared community- and course-based projects cultivated faculty and student relationships between the collaborating campuses. Peer mentoring has been critical in NH STEM student success, and KCC continues to support between 20-30 peer mentors in the STEM Learning Center for fall and spring semesters. This peer mentoring model has also supported strong faculty-student interaction, active collaboration, and academically challenging curriculum and instruction. Relationships with industry continued to grow through annual research and internship fairs on campus, and relationships with K-12 partners flourished as KCC hosted the annual Honolulu District Science Fairs and the Physics Olympics.

Institutional support grew through the development of new transfer agreements, access to UH-Mānoa (UH-M) advisors, and new reverse transfer agreements developed through the collaborative work of the Vice Chancellor for Academic Affairs and the UH-M COE. Finally, new curriculum developments have been sustained at both campuses to support the rigorous preparation and success of NH students at UH-M.

South Dakota PEEC

The South Dakota PEEC, known as Oglala Lakota College, South Dakota State University, South Dakota School of Mines and Technology Pre-Engineering Education Collaborative (OSSPEEC), brought together Oglala Lakota College (OLC) with both of the mainstream engineering schools in South Dakota. At OLC, a Science, Engineering and Mathematics (SEM) transfer program already existed with an institutional core of trigonometry (three credits), calculus (ten credits), university chemistry and labs (eight credits), and university physics and a lab (eight credits).

The OLC students in the SEM program, however, had low persistence and completion rates for matriculating to SDSU and SDSMT. The OSSPEEC leadership hypothesized that the linear cognitive development model (Piaget, 1978) of the SEM curriculum was an underlying cause of low student persistence, and they adopted a more culturally-relevant model following Bruner’s (1960) conjecture that mastery of fundamental ideas of a field involves both grasping of general principles and the development of an attitude toward learning and inquiry, guessing and hunches, and the possibility of solving problems on one’s own.

The OSSPEEC provided resources to redesign a pre-engineering curriculum more closely aligned with Lakota values, beliefs, and ways of being. They realigned classes and co-curricular activities to follow Kolb's learning cycle (D. Kolb, 1984 and 1999; A. Kolb & D. Kolb, 2005), which involves experimentation, observation, reflection, and abstraction. The Lakota world view was incorporated in the OSSPEEC model as the basis for making basically correct preconceptions, following Vygotsky's theories (1978) on the fundamental role of social interaction in cogitative development. In Vygotsky's words, "learning is a necessary and universal aspect of the process of developing culturally organized, specifically human psychological function" (1978, pg. 90). Lakota cultural values of *wawoohola* (respect), *Icicupi* (sacrifice), *waunsilapi* (compassion), *canteyuke* (generosity), *wayunonihan* (honor) and *wowacintanka* (perseverance), and opportunities to act as *tiospaye* (extended family) members were embedded into the program as co-curricular activities to meet reservation engineering needs in water quality, food sovereignty, and cultural preservation.

Preservation of the Wanblee Community Veteran's Wall was one of the first OSSPEEC projects that fully incorporated Kolb's learning cycle and Lakota cultural values. Bryant High Horse, a Native Lakota speaker and member of the Oglala Lakota Sioux tribe, asked OSSPEEC leadership to investigate the feasibility of preserving the first Veterans' Memorial wall on the Pine Ridge Reservation. The sandstone memorial was built by High Horse's grandfather and included the names of the residents of the Pine Ridge Reservation who served in World Wars I and II. The veterans' wall, which was located in front of the original Crazy Horse School, was relocated to the new Crazy Horse School in 1970's following a fire.

Thereafter, OLC and SDSMT pre-engineering students met with community members to design the Veterans' Memorial preservation alternatives over the first two years of OSSPEEC. The final designs presented to the Wanblee community included: 1) recasting the wall in concrete, 2) replacing the names with composite panels, and 3) a no-action alternative. The community decided on the no-action alternative in the third year of the project, and students demonstrated *wawoohola*, *waunsilapi*, and *canteyuke* in how they accepted the community's decision. The OSSPEEC leadership is maintaining the greater vision of *wayunonihan* of Pine Ridge Reservation's veterans through *wowacintanka* by growing community support for a community garden in the village of Wanblee at the Veterans' Memorial location, and in Rapid City at the OLC *He Sapa* campus.

Three aspects of cultural persistence are directly affected by institutionalization, and they include the following: 1) transmission, 2) maintenance, and 3) resistance to change. Institutionalization may increase all three. The Wanblee community Veterans' Memorial wall project provided a template for how Native engineers can solve problems facing TCUP-serving communities by adopting Lakota cultural values. The OSSPEEC leadership incorporated this approach into other projects to grow community stakeholder support. The efforts evolved into annual stakeholder listening sessions, initially organized by OSSPEEC leadership, and now organized by community stakeholders. The listening sessions provide a place for OSSPEEC leadership and the stakeholder community to come together to discuss needs, to align resources, and to identify collaborations such as Geographic Information System (GIS) data sharing and Global Positioning System (GPS) data standardization. The OSSPEEC co-curricular approach to teaching pre-engineering was institutionalized when the following occurred.

1) The South Dakota Board of Regents and the OLC Board of Trustees signed a matriculation agreement to allow course transfer between South Dakota Regental institutions and OLC;

2) NSF provided support for an EPICS curricular design program (NSF grant 1525831) in which student teams partner with local and global community organizations to address human, community and environmental needs (EPICS staff, 2016); and

3) OLC adopted, as part of the Institutional Strategic Plan, applied research to meet reservation community needs.

CONCLUSIONS

The Hawai‘i and South Dakota examples suggest different approaches to institutionalization, although both recognize the need for campus leaders to be much more engaged with sustainability and engineering issues, challenges, and opportunities in their local communities and the ecosystems they inhabit. By doing so, each college makes a tangible and lasting commitment to the long-term achievements of NH and NA scientists as they confront engineering's academic rigor and come to understand its relevance for their communities. Ideally, academic success and community health and sustainability are goals that must feed back into long-term institutional directions. The support of institutional administrators matters.

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A work crew installs solar panels on a building at the College of Menominee Nation's (CMN's) Keshena campus to support applied research by CMN faculty, engineering students, and others engaged in the College's Solar Energy Research Institute. (Photo credit: CMN by DKakkak)

14.

Obtaining permission to work on reservations: About IRB/RRB regulations

Norm Braaten (SD) and Wiyaka His Horse Is Thunder (SD)

INTRODUCTION

Tribes, colleges, and universities often have Institutional Review Boards (IRB) or Research Review Boards (RRB) with accompanying federal, state, local and tribal regulations that must be met in order to gain permissions to work with human subjects or to work on tribal lands. These boards and officers make determinations about permissions or lack thereof, involving the completion of many forms and perhaps personal appearances before the boards.

Why do we have a chapter devoted to this topic? In short, Native Americans (NA) and non-Natives (nN) may have vastly different perspectives when it comes to their approaches to and thoughts about research. This comes from different historical and cultural perspectives. Admitting the problem may be the first step to understanding, so that nNs "get it."

Historically, Native populations have not always been treated with respect when individuals conduct human subjects' research. To illustrate the point, consider an injustice done to the Havasupai Tribe that resonated throughout NA communities. A result was that various tribes established IRBs and research ethics boards to ensure that history would not repeat itself. In the case of the Havasupai in northern Arizona, the tribe, the university involved, and the Principal Investigator (PI) all have different interpretations of what took place and why. The following is a summary of the main points.

The Havasupai are a small NA tribe living near the Grand Canyon. Their settlement, Supai, is accessible only by foot, horseback or helicopter. In 1989 the tribe approached an anthropologist from Arizona State University to get help with managing diabetes that afflicted large numbers of the tribe

(Sterling, 2011). One theory proposed was that the Havasupai may have a gene variant that made them prone to the disease. As it turned out, they did not. A geneticist was brought in to assist, and blood samples were collected. The geneticist had other research interests aside from diabetes and may have pursued them without the knowledge and the consent of the tribe or the individuals. Those research interests appear to have been a dead end, as was the diabetes research. This could and should have been the end of the story. Unfortunately, the blood samples from the tribal members were retained; the genetic material was used in other studies at Arizona State University and shared with at least three other universities, resulting in several studies unrelated to the original intent of the permissions obtained (Whoownsyourbody.org, 2007). The result was individual and group harm. Clearly the intent of the study was to examine risk factors for diabetes; so why were other studies conducted without the consent of the individuals or the tribe? The majority of opinions agree that consent was inadequate. The tribe believed that they were giving consent for a diabetes study, while the university and PI appeared to believe that other uses for the blood and genetic material were acceptable. They were not. One minority opinion attempted to clear the original PI of acting inappropriately (Lewis, 2013). It was a time, the early 1990s, when all the aspects and challenges of genetic research had not been considered.

ETHICAL FOUNDATIONS

Human subjects' research is research involving, and about people. It is guided by ethical principles which accompany regulations overseen by the primary oversight agency, the Office for Human Research Protections (OHRP). While there are at least three sets of ethical principles, the most common set used by organizations who conduct human research are those in the *Belmont Report* (OHRP, 1979). Drafted by the 11-member National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research from 1976 to 1978, the Belmont Report serves as the foundational code of ethics for almost all U.S. organizations conducting human subjects' research today. Its three principles are (a) respect for persons, through informed consent and additional protections for those who are unable to provide consent; (b) beneficence, which calls for the inflicting of no intentional harm and a maximization of benefits along with a minimization of any risks; and (c) justice, an equal sharing of risks and benefits among all possible research participants. An activity must be ethical, or it should not be considered for approval.

IS THIS AN INSTANCE OF HUMAN SUBJECTS' RESEARCH?

In accordance with federal regulations and professional practices, an activity determined to be ethical could be divided into one of the four following categories:

1. Something that is not human subjects' research;
2. Human subjects' research that is exempt from regulation;
3. Human subjects' research eligible for expedited review; or
4. Human subjects' research that requires IRB (committee) review.

For something to be human subjects' research it must meet the definitions of "human subject" and "research." This is the first determination that an institution must make; if an activity does not meet the definition of human subjects' research, it requires no oversight by an IRB.

According to the Common Rule, a human subject is: "A living individual about whom an investigator (whether professional or student) conducting research obtains 1) data through intervention or interaction with the individual, or 2) identifiable private information" (45 CFR 46. 102 [f]) (OHRP, 2009). Research is defined as "a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge" (45 CFR 46. 102 [d]) (OHRP, 2009).

How does this relate to Pre-engineering Education Collaborative (PEEC)? Engineering activities may not necessarily be human subjects' research. Most engineering activities might not be about people; instead they might be focused on devices, processes, or infrastructure. They often do not fit the specific definition of research; instead, they may be projects designed to get things done. They are not necessarily about discovery.

PEEC program evaluations may or may not be human subjects' research. Is there a research *intent*? Are PEEC participants simply attempting to complete a project and see how it went (not research) or are they trying to create a project that can be replicated across the entire NA population (research)? It could be argued that none of the individual PEEC projects had a research component. A meta-analysis, on the other hand, is human subjects' research. For example, if all PEEC projects were combined and analyzed together, patterns or general themes might be discovered.

Exempt human subjects' research
The first category that human subjects' research may fall under is "exempt from the regulations." A single reviewer (and not a committee) may make an exempt determination if the human subjects' research meets one of the criteria that allows an activity to be exempt from the regulations. There are six exemption categories: (1) educational (classroom) research; (2) educational testing, surveys, interviews, and observation; (3) surveys or interviews of officials in elected or appointed political positions; (4) use of existing data; (5) activities or programs that a federal agency (or federal law) declares to be exempt; and (6) food tasting. A complete list of exemptions can be found in the regulations, 45 CFR 46.101 (OHRP, 2009).

PEEC activities often used methods found in exemption category 2, and many of the activities may have fallen under the educational research exemption category 1. An explanation of those two categories may be instructive, a follows.

Exempt category 2 excludes the following from the regulation,

> *[R]esearch involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects financial standing, employability, or reputation.* (45 CFR 46.101 [b] [2]) (OHRP, 2009)

Exempt category 1 addresses the following:

> *[R]esearch conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.* (45 CFR 46.101 [b] [1]) (OHRP, 2009)

PEEC is about getting NA and Native Hawaiian (NH) students interested in and prepared for careers in engineering followed by successful matriculation into and through an engineering program. Gauging interest is most often done through surveys and interviews. Much preparation is classroom-based educational instruction and testing. New and unique teaching methods may be employed and compared with prior methods. Hands-on activities may round out the experience. Exempt categories 1 and 2 would clearly appear to apply.

Beyond exempt

Activities that are not human subjects' research and those that are exempt have the same regulatory effect. They are outside the regulations. We should also briefly turn our attention to those human subjects' research activities under the regulation.

Human subjects' research that does not fit under one (or more) of the six categories that render it exempt from regulations, must be reviewed in accordance with the regulations, either through expedited review, which encompasses several activities determined to be minimal risk. A single IRB member or a subcommittee of the IRB may perform this review. Finally, some human subjects' research requires committee review—those activities having risks that cannot be completely minimized. Although IRBs may differ in their interpretation of the regulations, and a higher level of review is always acceptable, most IRBs would probably not need to use methods beyond "exempt" to review and approve PEEC activities.

Challenges

Human subjects' regulations are focused on the individual and do not necessarily take into consideration community harms and benefits. The ethical principles found in the Belmont Report do not concern themselves with groups, nor do the federal human subjects' regulations. However, when NA or NH communities are involved, community harm and community benefit should be considered. Tribal sovereignty must be respected. Prior to working on reservations and in addition to approval of an activity at one's home institution, approval should be sought from the tribe's IRB, research ethics board, or from a designated unit of tribal government, such as a tribal college IRB. Tribes can add to the regulations in ways that are culturally relevant to their situation and their needs. Their cultural input into all activities, whether they are human subjects research or not, must be present.

Sometimes a tribe and a tribal college may be involved in determining approval or lack thereof concerning human subjects' regulations. South Dakota's PEEC projects involved a tribal college board, and in some instances, also the tribe or the reservation board. Who solves the issue of tribal college versus tribe if disputes arise? The answer is partly dependent on jurisdiction, partly on relationships, and perhaps partly on politics.

A tribe could have different levels of review for different activities. Activities that directly impact the culture (sharing stories/lore) might carry the highest levels of oversight and possibly, restrictions. All human research might require local committee review, with exempt approvals and expedited review not allowed. Other projects, such as those that are not human subjects' research might only require a single person signing off, or might also require the approval of a review board. Some activities might never be approved.

Another challenge faced by IRBs is how to approach research that involves NA students off tribal lands. Should tribal sovereignty follow? Another challenge may be differences of opinion about what constitutes "research" and what does not, between mainstream universities, tribal colleges, and tribal governments.

PEEC STATE EXPERIENCES IN GETTING APPROVALS

As explained in the previous sections, a case could be made for all PEEC activity to be ruled as not human subjects' research or exempt human subjects' research. This, indeed, turned out to be the case. One of the state PEEC projects was determined to not be human subjects' research and the other three states chose to use an exempt determination. In either case, as noted, these determinations both had the same regulatory effect.

The following insight detailing the PEEC review and approval process is instructive. At one site a brief discussion was held regarding whether or not the planned activity was human subjects' research or if it fell under the exemptions. There was some discussion, and, after careful consideration, the activity was approved as exempt human subjects' research. Tribal approval was also sought and was obtained; however, some things were not approved, specifically some of the educational tests that may have contained built-in cultural biases.

Some PEEC leaders also sought permission to conduct projects on tribal lands, although in some states, no work was conducted on tribal lands. In those instances PEEC activities occurred at the PEEC host institutions or outside reservation boundaries.

Another unique insight may be gleaned from the Menominee Nation in Wisconsin. The College of Menominee Nation has an IRB, and tribal approval is required when individuals seek permission to conduct activities on the Menominee Reservation. Approximately 97 percent of Menominee lands are forested, and the forest is thoughtfully managed. Permission to visit or work in the forest is tightly controlled, and may be a good example of when permission might never be granted, given the tribe's reverence for the land and forest.

CONCLUSIONS

A good human subjects' administrator takes every opportunity to provide insight into the human subjects' review and approval process.

South Dakota State University has informally adopted the following guidelines to supplement the human subjects' regulations when working on human subjects' research projects designed to benefit NAs.

- Tribal council, tribal president, and/or RRB permission must be sought and documented.
- Evidence of cultural input must be demonstrated.
- Community harms and benefits must be discussed.

Everything begins and ends with respect. It is the first ethical principle of the Belmont Report. When working with Native communities, the principle in the Belmont Report must be expanded from its "respect for persons" to respect for the community and culture. Any project or activity occurring on tribal lands requires permission and respect. In fact, respect should be expanded to everything, in every situation, including living and non-living entities. Non-Natives may neither be attuned to Native cultures nor to their history of oppression by the dominant culture surrounding them.

Perhaps one of the best insights into working with NA communities derives from a paper developed collaboratively by the National Congress of American Indians (NCAI) Policy Research Center, and Montana State University's (MSU) Center for Native Health Partnerships (NCAI and MSU, 2012). The following is some of their advice.

> *Developing ethical and meaningful research partnerships with AI/AN [American Indian/Alaska Native] communities requires researchers to understand and commit to an ongoing process of authentic and deliberate relationship-building, cross-cultural learning, open communication, trust, and reciprocity. This is especially important for tribal leaders and communities in protecting knowledge,*

> *culture, and beliefs in the research process while also providing benefit to their tribal citizens.*
>
> *Tribal nations are diverse. Each tribal nation and each research project and team is unique. Additionally, developing effective relationships cannot be accomplished from behind a desk or without active, in-person participation in the community. Partnerships between tribes and researchers require an orientation to research that is both culturally-based and community-centered.*

We all should “walk softly and listen carefully.” (NCAI and MSU, 2012)

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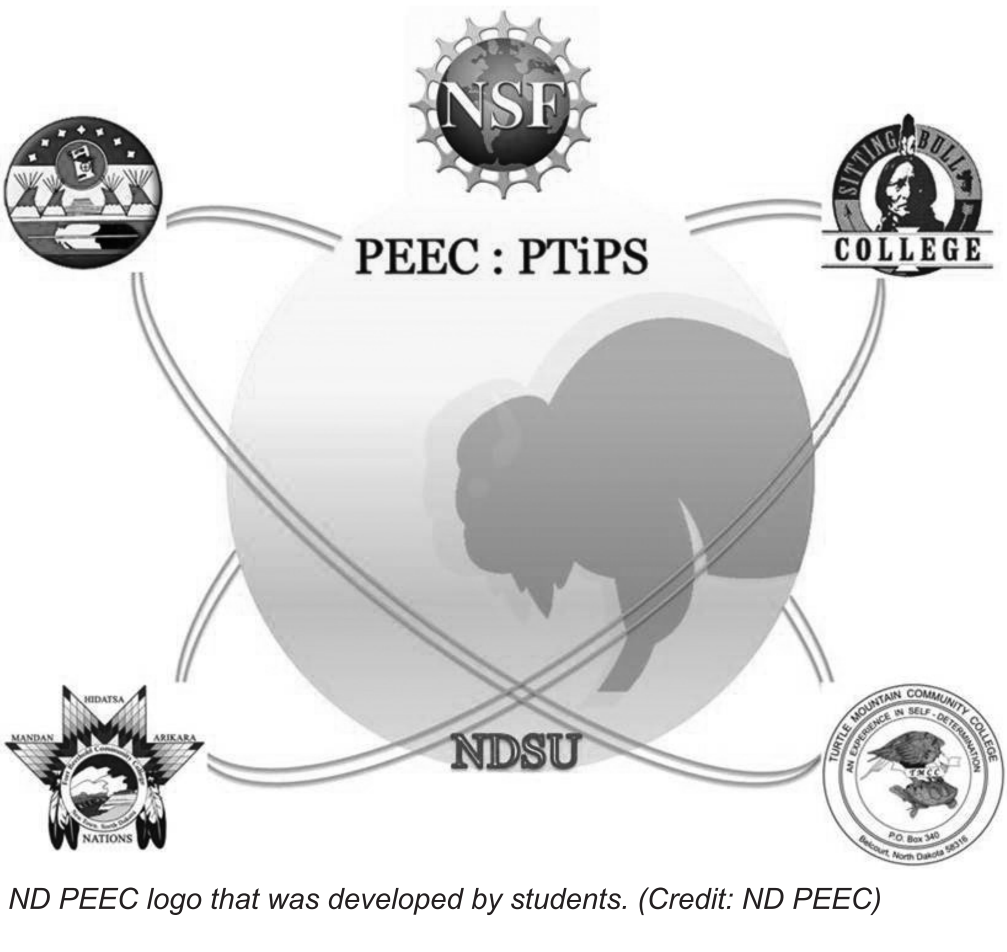

ND PEEC logo that was developed by students. (Credit: ND PEEC)

15.

Involving STEM teachers with tribal faculty in PEEC: Joining forces to serve undergraduates

Robert Pieri (ND), Carol Davis (ND), G. Padmanabhan (ND), and M. R. Hansen (SD)

INTRODUCTION

The curiosity of youth is universal and transcends geopolitical boundaries and cultural differences. It should be cultivated and directed for the improvement of the community. There is no geographical limitation on intelligence, but there are differences in educational opportunities. The Tribally Controlled College (TCC) system was initiated in the late 1960's to try to balance inequities in educational opportunities, just as the Morrill Act of 1862 established land-grant institutions for the betterment of post-Civil War American society. In the more than 100 years separating the two movements advancing postsecondary education, much has changed and much as stayed the same for all the stakeholders in both systems.

Constructivism is a popular educational theory that might be interpreted as learning based on prior experience, i.e., what makes sense for the first grader is something that supports that first grader's world, although it might be a new concept or idea. Similar interpretation at the post-secondary level would imply a need to build education on a foundation of experiences that are broad and strong and solid. Unfortunately this foundation is not always found in some products or Native Hawaiian (NH) or tribal school systems, which is not to say that the systems are faulty, but that they exist in a complex context, a context that is often quite foreign to many stakeholders at mainstream institutions. Although the motivation to educate students is similar in most situations—the resources, the environment, and the process can vary tremendously among institutions. The thrust of this chapter will be to consider how to utilize that common motivation to span the differences in opportunities.

To the outside observer, the lack of adequate STEM preparation and academic intervention programs available for college and pre-college students could be factors contributing to low participation and completion rates of engineering degrees by Native Hawaiian (NH) and Native American (NA) students. Programs to alleviate these concerns focus on steps external to the student, such as providing smooth and seamless NH and NA student pathways from K-12 through community and tribal colleges to universities. But there is not a conscious and unified addressing of student motivation or perception of their world and the opportunity afforded to these students by seeing and experiencing STEM-related opportunities at the local level and beyond. This gap perhaps leaves the student with a “Why should I care? It’s not going to make a difference!” attitude.

Teachers at tribal K-12 schools, as well as faculty at tribal colleges, need to be made familiar with simple engineering concepts in order to integrate them into their teaching, but they lack a context to do so. They also need skills in engineering pedagogy. Mainstream university faculty, for their part, need to understand the mechanisms of college and pre-college teaching methods and cultural sensitivity. One way to increase tribal college faculty expertise in fostering students’ attitudes toward STEM preparation is for tribal college faculty to “collaborate” with engineering and STEM faculty in mainstream universities. It is in this collaborative context that programs such as PEEC (Pre-Engineering Education Collaborative) assume great importance. However, collaboration needs to be redefined because tribal and mainstream instructors have different points of view as to what collaboration means and entails. This is complicated by different professional objectives for mainstream instructors, tribal college instructors, and K-12 instructors and administrators.

Strengthening the STEM content and especially the “E” for engineering in this context, by including meaningful application of theory and hands-on activities, may go a long way towards providing students with better preparation to evaluate potential career choices. This form of advancing STEM faculty is a crucial component of the overall capacity building effort in NH-serving and NA-serving undergraduate institutions. All PEEC programs have this aspect of collaboration between community colleges and mainstream universities built into their activities in one way or another. Faculty experiences of PEEC in North Dakota (ND) are highlighted below.

North Dakota

The North Dakota (ND) PEEC was built in 2010. It was fully titled “PEEC: 2+2+2+Infinity: Pipeline for Tribal Pre-engineering into Society” (PEEC:

PTiPS). It was a natural evolution of the collaborative framework that developed between ND TCC's and North Dakota State University (NDSU) in the 1990's in a project sponsored by the Office of Naval Research (ONR) trying to get underrepresented students into technical fields. This program was repackaged into an NSF-EPSCoR sponsored program titled Nurturing American Tribal Undergraduate Research and Education (NATURE) program in approximately 2005. These programs are described elsewhere in this publication (Davis, et al., 1998; Davis, et al., 2000; Padmanabhan, et al., 2002; Padmanabhan, et al., 2004; Lin, et al., 2007; & Davis & Padmanabhan, 2008). Mutual visits by NDSU and tribal college faculty at their campuses during activities from these programs such as Sunday Academy, and Summer Camps, proved to be a first step in strengthening the collaboration at the faculty level.

During the 2003-2004 academic year, co-author Pieri took a year-long sabbatical to join the faculty at one of the TCCs in the state, Turtle Mountain Community College (TMCC). During this experience, Pieri gained many insights into the operation of tribal colleges, especially in comparison to mainstream postsecondary institutions. Concepts or titles such as "tenure," and the titles "professor" and "teaching assistants" (TAs), are often unusual in TCC life. At tribal colleges, class loads for instructors tend to be several factors higher than at mainstream institutions, often including five classes per semester with 15 to 25 students in each class. For example, Pieri taught five or six different classes in his one year sabbatical.) At tribal colleges, involvement in the local community is also greater, with parents and family members often meeting instructors at many venues. A North-Central institution accreditation took place during Pieri's sabbatical year which was viewed in light of several Accreditation Board for Engineering & Technology (ABET) accreditations that Pieri experienced. Pieri's sabbatical experiences, including these and others, led to a personal revelation of the many differences in professional objectives between ND tribal colleges and mainstream institutions. These differences form the context in which both systems operate as they strive for student education and success. These differences of context, for both institutions and individual instructors, act as different lenses of focus for collaborative actions among participants.

Subsequent to this experience, in fall 2007, Pieri had the honor of being named by the president of NDSU to a position that became "Coordinator, TCC/NDSU Partnerships." This position was created to lead an effort to enhance the partnerships between all ND tribal colleges, "1994 land grant" institutions; and the State 1862-land-grant university and their Extension Service component. The effort was to focus on identifying opportunities for enhancements of cooperation and communication between components and departments within tribal colleges and departments and agencies within NDSU and the ND Extension Service. This allowed Pieri to put more than 40,000 miles on a vehicle, driving between institutions during the three years in that position and to become even more familiar with the operation of TCCs in ND and beyond. (It should be noted that TCC can be nearly interchangeably used with “TCU,” which is “Tribal College / University,” since many institutions, on a national basis, performed name changes.”)

It was during this partnership activity when the NSF RFP (Request for Proposals) #10501 hit the streets in October 2010. It was the request that eventually led to the PEEC program. This RFP was a result of a meeting held the previous February in Washington, D.C., including leaders from tribal colleges and other minority-serving institutions. The purpose of the meeting was to see what could be done to increase STEM education and, in particular, engineering education in TCUs.

The Dean of Engineering from NDSU and Pieri attended the Washington meeting and offered to the NSF program managers a proposal that could be delivered within a few weeks. When the actual RFP did come out, Pieri consulted with several people on the NDSU campus about components that should be included within the proposal. It was a fundamental tenant of the proposal that some funding should go towards supporting degreed engineers as part of each tribal college PEEC teaching contingent. These individuals would be able to supply an engineering point of view to the two outcomes of the proposal: engineering education and community improvement. Other basic tenants in the core proposal included guidance provided by three advisory boards, Instructional, Administrative, and Professional. These advisory boards would address components of engineering instruction, program administration, and post-graduation career development, respectively, for the ND PEEC program.

It took many miles of travel and hours of meetings with tribal college presidents, vice presidents for academics and associate TCC administrators asking for their input and working out details to build support among the institutions. It was also recognized that because of ND weather and the distances between participants, distance education had to be a key component in the program. This was recognized as being in conflict with the need to establish personal relationships for success that came out of previous ONR and NATURE programs.

Even at this point, the process was not totally smooth because another group at NDSU, with ties to the original ONR and NATURE programs, was offering a proposal, but their traction with the tribal college leadership was not as coordinated. This other proposal represented a bit of "the old way" of involving TCCs; that is to say, it represented a position of "We have written this proposal and we think it is in your best interests to sign on to this. Please do so." While the ND PEEC proposal was written from the mindset of "There is this opportunity; . . . what would you like to include in it to help your program? Okay let's discuss that." The components described above were modified by the tribal presidents, and consensus was built. The resulting structure is shown in Figure 1.

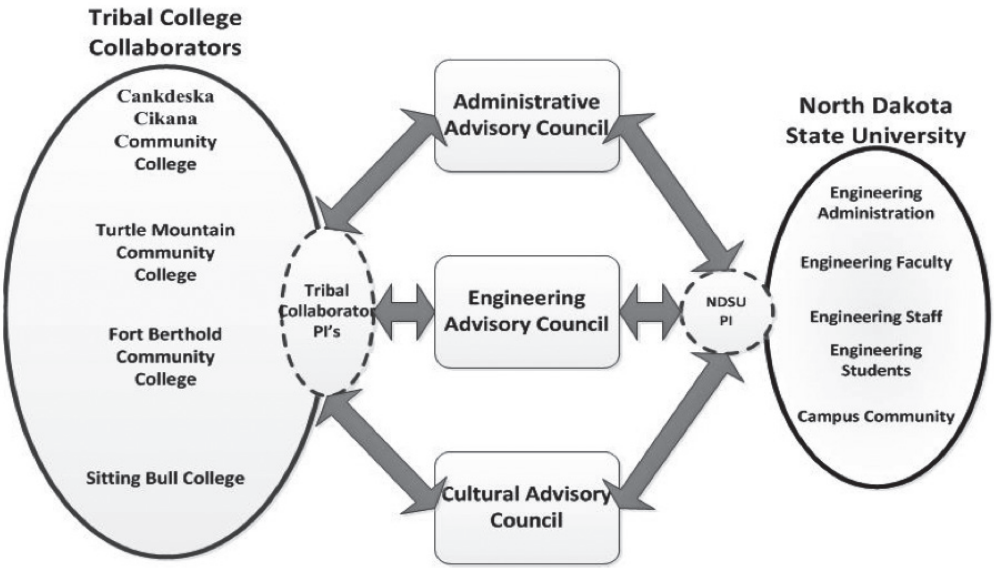

Figure 1. Structure of ND PEEC: PTiPS program at the end of the first year. Note: "Cultural Advisory Council" was added when the engineering educational and the engineering career councils were merged allowing continued cultural relevance for the program. (Credit: ND PEEC)

When the proposal was submitted to NSF, the participating TCCs included Cankdeska Cikana Community College (CCCC) as lead institution with "Russ" McDonald as collaboration PI; Turtle Mountain Community College (TMCC) with Loretta Hall, TMCC PI; Sitting Bull College (SBC), with Gary Halvorson SBC PI; and Fort Berthold Community College (FBCC) (since renamed to Nueta Hidatsa Sahnish College, NHSC), with Clarice Baker-Big Back FBCC PI. (The fifth North Dakota TCC, United Tribes Technical College (UTTC), was already participating in a pre-engineering program with the Nuclear Regulatory Agency.) The participating ND mainstream institution was NDSU with Robert Pieri as NDSU PI.

As the ND PEEC began operation, it became apparent that interaction with the administrative advisory board would be a significant aspect of getting the program off on the right foot. Initially, the meetings were held once or twice a semester at rotating sites to build trust and confidence in the program. These meetings also allowed the engineers to illustrate to college administrators the particular opportunity available in having a pre-engineering program in their curriculum.

The opportunity included items such as: flexibility of on-site engineering instructors to handle their courses, as well as additional mathematics offerings, the ready access to STEM-specific funding opportunities, the recognized prestige of intensifying their curriculum by offering an engineering option without the added expense of laboratories, and support faculty.

The collaboration administrators were also made aware that these options came with needs that differed from their existing program offerings. The needs included items such as distance education access (available slots on the existing Interactive Video Network [IVN]), reduced teaching loads for on-site engineering educators allowing them more tutoring opportunities, special textbook and technology support items, and recruitment needs from the local high schools, among others.

Also identified in these meetings with administrators was the goal of establishing memorandums of agreement/letters of understanding with respect to transferring students between TCCs and mainstream institutions. Although not all the above items were carried toward completion as initially intended, the need for all were recognized and work was completed, to varying levels, on all the mentioned aspects. In essence, this allowed for definition of the extent of faculty enrichment required to serve the needs of the student cohorts (Pieri, et al, 2013b). The reality of the TCC operating condition is that of all the PIs named on the initial submission above, none of the TCC PIs still remain associated with the grant and most are no longer with that institution. This illustrates that any significant outreach activity cannot be thought of as a “one and done” sort of process, as the Hawaiian collaborators so eloquently described in this book. The process needs continual attention.

The TCC faculty engagement and development was carried on through the on-site engineering educators. This provided for firsthand understanding of educational needs of an NA engineering student and some of the expected caution areas. Although, the ONR and NATURE programs provided some opportunity for TCC faculty and mainstream engineering faculty to work together, there were missed opportunities. For example, lack of mathematical skill sets in TCC students was one of the major impediments recognized by preceding programs in the successful transition of high school students to the TCCs and the tribal college students to universities in the STEM career fields, particularly engineering (Davis, et al., 1998; Davis, et al., 2000; Padmanabhan, et al., 2002; Padmanabhan, et al., 2004; Lin, et al., 2007; & Davis & Padmanabhan, 2008).

One major component of the ND PEEC was an annual twelve-day summer camp held at NDSU. Students attending the camp came from participating TCCs. Engineering instructors from the colleges also attended the camp in a separate track of professional development activities designed for them (Pieri, et al., 2013a). Typical activities for the instructors included sessions on assessment, incorporation of distance education strategies and technology in their courses, active learning strategies, and a trip for the instructors to an engineering curriculum conference held at Alverno College, Milwaukee, Wisconsin, from June 11-13, 2012, to obtain first-hand experience with outcomes-based curriculum design.

Immediately after this session at Alverno College, a major student activity was added to that summer's camp. It was a scenario exercise in which the students were able to demonstrate professional communication skills which the engineering instructors were able to analyze and evaluate with respect to how well the courses they taught aided the students with critical thinking skills. All of these experiences allowed for comparative evaluation by the engineering instructors of their TCC program to national programs with respect to components such as ABET accreditation. The thinking here was that by providing the on-site engineering instructors with such experiences, they would be in a better position to self-evaluate their program. However, it should be noted that over the six years of the program (5+ one-year extension) if one thinks of it as 24 instructor-semester positions funded by the proposal at each TCC over the course of the program, the current seven engineering and mathematics instructors have filled approximately 56 of the available 96 semester slots, indicating a relatively high turnover rate.
Most teachers in North Dakota's reservation high schools, as well as others across the nation, have high teaching loads and some are inadequately prepared or equipped to explain science and engineering concepts in ways that interest students and motivate them to pursue careers in STEM. One of the reasons identified for declining interest among high school students

in mathematics and science is the way these subjects are taught in high schools. With their varied academic backgrounds, many K-12 reservation teachers are responsible for instructing students in a variety of different subjects. In some STEM subjects, those teachers are not certified as qualified in accordance with local State standards for K-12. There is clearly a lack of information and resources for high school teachers to improve their knowledge and readiness to spice up their teaching with applied examples and hands-on activities (Padmanabhan, et al., 2002). The situation at TCCs may not be much better, since a large portion of their college teaching staff actually comes from high school programs, and teaching loads are also high and very diverse.

Each of the PEEC collaborations handled this interface with their TCC partners a bit differently. The ND collaboration of four tribal colleges and NDSU is unique in the nation because of their on-site engineering instructors. The collaboration has successfully developed pathways on reservations for NA students aspiring to pursue STEM careers in engineering, while still maintaining family, community, and cultural ties. The solid tribal college-university collaborative platform established via ONR and NATURE served as the starting point for the evolutionary development of the ND PEEC program. On-site engineering instructors working through the mainstream PI and support staff have identified K-12 and TCC opportunities that could lead to the creation or strengthening of existing or new NA student pathways to realization of career aspirations they may have only dreamed about.

The on-site engineering instructors have been able to extend the outreach and recruitment to local and tribal high school systems, as reported elsewhere in this book. This involvement of the on-site engineering instructors with local schools and the community affords several advantages. Some of these include a familiarization with the culture and an understanding of local economic problems, and timely information about curriculum changes that could affect the pipeline flow of students within the program.

This illustrates another difference between mainstream institutions and TCCs: the ability, or perhaps the need, to react to the local community's situation. As an example, when the recent reduction in activity in the ND oilfields occurred, some of the schools were able to see a rapid increase in the potential pre-engineering students. This was reflected in some scheduling decisions and teaching assignments. This, in turn, reflects a response to student needs that most other programs cannot supply. Other aspects of outreach by on-site engineering instructors are detailed in another chapter.

As stated above, attitude is an important part of the motivational drive with learning; however, the content remains important. Toward that end, mathematical instruction has to be maintained at a level that allows a reduced student stress about the transition from TCCs to the mainstream institution. This is true for all of the collaborations in the PEEC program. The most significant stress reduction about the transfer process seems to have two fundamental components. One can be thought of as students' self-confidence in their own mathematical skills, earned through understanding that they have completed a rigorous program, directly supporting their plans and goals. The second component is adaptability to the soon-to-be new surroundings at the mainstream institution.

An example of this last component is the method of mathematics instruction. At the TCCs, the class sizes, even with distance education and combined enrollment, means that one instructor is continually with the class, interacting with all of the eight or ten students participating. When the same students transfer to the mainstream institution and enter calculus II or III or differential equations, they will be in lecture halls of perhaps 30 to 100 students in classes taught by a professor, and then in a 20-person recitation section using graduate TAs, perhaps not recognizing a single face in the room. And this may be the first time that the transfer students have ever encountered recitation style format. Just as it is with distance education, the first time they experience it, the new transfer students do not exactly know how to optimize the situation for their own learning needs.

Another example of a change of pedagogy is the extensive use of online homework at mainstream institutions. Most of the TCC on-site engineering instructors have some responsibilities teaching linear algebra or one of the calculus courses for which they have not had direct training. This in-service training is also part of the program's summer professional development activities.

A huge benefit from the presence of the on-site engineering instructors is their dedication to student learning. The eight instructors, who are or have been in the program, all had that same characteristic, although sometimes expressed in different fashions. This type of encompassing student support that is often seen at the TCCs, was reinforced with the on-site instructors. It was sometimes verbally described as wrapping protective wings around the student. This situation needs to be maintained at the mainstream institution and is a significant role for the PI there. The mainstream institution does, however, have some valuable resources in this area in that it often has more formal and organized support systems available, such as the offices of Student Support Services, Tutoring, TRiO, Disability Services, Student Counseling, and Student Health Services. All of these on-campus offices supply services that can aid the transitioning of transfer students, but the problem is getting the student to recognize the utility of using these resources.

South Dakota
The effort in South Dakota included collaboration between Oglala Lakota College (OLC), South Dakota State University (SDSU), and South Dakota School of Mines and Technology (SDSMT).

An SDSMT faculty member, M. R. Hansen, taught Construction Materials at OLC, cooperatively with SDSMT. This is a course that he taught many times at SDSMT, and the decision was made to teach an equivalent course at OLC with Hansen's colleague, Al Schwalm. The course had lecture and laboratory components. With the assistance of OLC faculty member Jason Tinant, Hansen and Schwalm researched the facilities at OLC and established a testing laboratory in a corner of the garage. The SDSMT donated a hydraulic press to OLC by way of a long term loan for the laboratory. Other challenges were to establish a secure storage area for laboratory tools and equipment. The final goal was to leave an ongoing working laboratory at OLC for future use.

Leaders for the course decided to offer the lecture at the OLC campus at Rapid City with some students attending there, and some attending via distance facilities at OLC. The lecture was one two-hour session per week at Rapid City and one three-hour lab session per week at OLC at the *Piya Wiconi* campus near Kyle, SD.

The technical lecture material from the mainstream university partners was delivered with all notes transferred to Schwalm. Attendance by the students was hit-and-miss, since they were responsible for being on time at all locations. For the labs, course leaders collected all of the students from Rapid City and transported them to OLC where they joined other students. Students performed the lab activities, and faculty assigned lab reports as homework. On at least one occasion, the students met at the materials lab at SDSMT and had a lab testing demonstration of advanced composite materials.

An additional feature of this course was that all students took certification exams from the American Concrete Institute. These included the American Concrete Institute Field Testing Technician Grade I and Aggregate Testing

Technician exams which are recognized worldwide. Both exams included written and performance components and, when completed, the students received a certificate that was valid for five years. At the end of this course, the coordinators built capacity at OLC, having established an equipped lab and establishing a course and track record of offering American Concrete Institute certification exams.

An Engineering Surveying course was taught cooperatively between OLC, SDSU, and SDSMT. Initially, faculty member Jason Tinant at OLC taught the course cooperatively with Bruce Berdanier, SDSU PEEC PI, a Professional Engineer and Land Surveyor and faculty member at SDSU, with equipment provided by SDSU's Civil and Environmental Engineering Department for use in the course and also for the experiential learning projects.

As the offering of the Engineering Surveying course evolved, it had a lecture component of two hours per week taught via distance education facilities at the OLC Rapid City, SD, campus, with the Rapid City-based students attending at Rapid City and the remote students attending at the distance education facilities at *Piya Wiconi* OLC campus near Kyle, SD. For the lab exercises, the faculty collected the students at Rapid City and traveled with them to meet other students at the Kyle campus of OLC. Together they conducted real surveying projects around the campus and at the project sites in the area.

The lecture exercises used real data collected in the field, and the students analyzed the data using spreadsheets as homework. For laboratory projects, when a blizzard raged outdoors, students used real data to draw the maps to scale by hand on drafting paper. The students produced accurate, professional and attractive drawings that they could show with pride to future employers.

This course is well implanted into the OLC curriculum, especially since OLC faculty member Jason Tinant uses the skills developed in this course in the experiential learning projects that students have as part of their degree program. The course now has an integrated set of lecture notes derived from two registered professional land surveyors, numerous computer programs, and a complete set of surveying equipment. An OLC student can take this course at the *Piya Wiconi* campus of OLC with full transferability to SDSMT or SDSU.

Another course, Introduction to Engineering, is taught at both SDSMT and SDSU, and SD PEEC leaders were confident that they could teach it at

OLC, and it would be fully transferable to SDSMT or SDSU. The purpose of this course was introducing the students to engineering analysis, working in teams, and working on public service projects. This course was taught entirely at SDSMT, since it was summer session and most of the students were living in Rapid City. Instructional personnel met at the materials lab at SDSMT and led activities.

One activity, led by SDSMT faculty member M. R. Hansen and OLC faculty member Jason Tinant, was to devise and construct a testing set up to measure deflection of an elastic material after incremental loads. After collecting the measurements, the students plotted the data on Excel. This gave them experience with working in teams to devise a simple mechanism in the lab, collecting the data, and analyzing and presenting the data in a professional manner.

Another activity, led by SDSMT faculty member Jennifer Benning, was to reverse-engineer various ordinary kitchen toasters. Initially, the teams compared the price, power consumption, functionality, human engineering aspects (including taste testing of the toast), and packaging. Then the teams disassembled the toasters and weighed the various materials and considered the recyclability of those materials. Finally, the teams compared the various aspects of the four types of toasters, devised a ranking scale, and recommended a toaster based on established engineering criteria.

Another example of an activity was led by Kristina Proietti, an SDSMT graduate student. The activity's objective was to promote the use of Lakota language by making a poster display on an engineering related topic. For example, students showed the sequence of steps to proportion, mix, cast, cure, and test a batch of concrete. Students took photos and wrote captions explaining the sequence of work in both English and Lakota languages.

In Fall 2011, Bruce Berdanier and Jason Tinant developed and offered a hybrid course on Principles of Environmental Science and Engineering. The course was offered in parallel at SDSU and OLC utilizing two-way audio-video transmission and taping lectures for later streaming resulting in Berdanier's driving to OLC numerous times to meet with students and staff. The course continues to be offered at SDSU and OLC and is part of SDSU's Bachelors of Science in Civil Engineering degree program, and OLC's Pre-Engineering degree program.

In summer 2012, a Civil Engineering 3D Computer Aided Design course was jointly developed by Allen Jones, a registered Professional Engineering and an SDSU faculty member, and James Sanovia, an OLC faculty member. Initially, the course was offered in Fall 2012 to three OLC students. There were two-way audio-video lectures with captured lectures available for streaming after class as needed by the students; digital course content in a course management system; and a set of lessons, activities and rubrics for teaching and assessment. The course is now part of the curriculum at both SDSU and OLC.

Additional activities included studying ethics, going on field trips, and working on community service projects. The students needed to adapt to whatever became available and to realize that the engineering world is full of challenges.

CONCLUSIONS

Although progress has been and is being made to improve representation of Native Americans (NAs) in the Engineering profession, there is much left to do in preparing NAs for careers in this discipline. A collaborative framework among tribal K-12 schools, tribal colleges, and mainstream universities is essential in accomplishing the goals of guiding NA students into STEM degree programs without extensive use of limited resources at the tribal college end of the pathway.

A collaborative platform with mainstream universities may facilitate K-12 school teachers and faculty from tribal colleges and universities in working together to support student learning. PEEC leaders at collaborating mainstream universities need to strengthen understanding of key concepts in STEM, particularly in engineering, among tribal college faculty so that they can deliver a more meaningful educational experience to students at tribal colleges. Those students can then use this information to determine a career path, and tribal college faculty benefit through career advancement.

North Dakota and South Dakota PEEC leaders tried a variety of activities and projects to discover what works in each setting. They reported that constructivism, in some form, was useful when combined with cultural sensitivity and local community relevance.

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Since the veterans' wall on Pine Ridge Reservation showed signs of weathering, it became a potential rehabilitation project for PEEC engineering students in 2011, but locals decided that it was preferable not to repair the damaged sections, because its natural deterioration holds more meaning for them. (Photo credit: Damon Fick)

PART V: Learning from experience

16.

Joining forces with unexpected PEEC-enhancing projects along the way: Unforeseen alliances in South Dakota

Jennifer Benning (SD), Hannan LaGarry (SD), and Charles Jason Tinant (SD)

INTRODUCTION

In South Dakota, many of the educational opportunities provided by the PEECs have been dramatically enhanced through serendipitous alliances between the PEECs and other organizations. This chapter describes the nature of some of these partnerships and the benefits provided.

SOME PEEC PARTNERS IN SOUTH DAKOTA

Oglala Sioux Tribe's Environmental Protection Program (OST-EPP)
Through a United States Environmental Protection Agency (US EPA) Environmental Education grant, South Dakota School of Mines and Technology (SDSMT) partnered with the Oglala Sioux Tribe's (OST's) Environmental Protection Program (EPP) on a two-year project that created a multi-tiered educational program with the goal of promoting water resources protection on the Pine Ridge Reservation.

The project involved an extensive partnership, including over 250 students and staff members of the Gaining Early Awareness and Readiness for Undergraduates Program (GEAR UP); Oglala Lakota College, South

Dakota State University, South Dakota School of Mines and Technology Pre-Engineering Educational Collaborative (OSSPEEC) students; OST-EPP staff; SDSMT staff and students; Bureau of Indian Affairs (BIA) personnel; Oglala Sioux Tribe (OST) Land Office personnel; and OST Natural Resource Regulatory Agency (OST-NRRA) personnel.

PEEC students worked with OST-EPP and an SDSMT graduate student funded by a US EPA grant on developing OST-EPP's capacity for conducting required water quality monitoring. In addition, PEEC students assisted in teaching, both in the classroom and in the field, over 250 NA high school students about field techniques for water quality monitoring. The involvement of PEEC students allowed them the opportunity to serve as role models for involved high school students (Marnach, 2013).

In creating synergies with this US EPA grant, Oglala Lakota College (OLC) began evaluating stream health with OST-EPP in 2010 focusing on macroinvertebrates, and taking over the role of watershed protection plan implementation reporting in 2012. The OSSPEEC provided a mechanism to catalyze event discharge and nutrient load evaluation, as well as providing Pine Ridge Reservation community members with informal science education opportunities in water resources protection.

Realized outcomes of the OSSPEEC, US EPA, and OST-EPP partnership included the development of load duration curves for nitrogen and phosphorus, confirmation of an OLC faculty member's hypothesis on nitrogen as the limiting nutrient in Pine Ridge Reservation streams, which provides a basis for a dissertation on hydrologic variability of reservation streams.

Native American Sustainable Housing Initiative (NASHI)
The NASHI is an initiative created by faculty member Rob Pyatt of the University of Colorado-Boulder (UC-Boulder) who seeks to address the needs for sustainable, affordable, and culturally-appropriate housing in NA communities. Supported by a United States Department of Housing and Urban Development (HUD) Sustainable Construction in Indian Country Small Grant Program, NASHI partnered with the UC-Boulder, OLC, and SDSMT to design, build, and test a net-zero energy home at the Thunder Valley Sustainable Community Development on Pine Ridge Reservation. Through this program, faculty and students from OLC have visited UC-Boulder during the planning phase of the project.

In the summer of 2014, 19 students and faculty from OLC and SDSMT participated in a week-long training led by Solar Energy International, where participants learned about the design and installation of grid-tied photovoltaics, and they earned certificates while they installed eighteen 5-watt solar panels on the research home (Pyatt, et al., 2015). Four PEEC students have also worked on monitoring the home for indoor air quality parameters that informed design. In addition, a PEEC graduate student, Kimberlynn Cameron, presented the results of the investigation at the International Society of Indoor Air Quality's Indoor Air conference in Ghent, Belgium, in July 2016. This project and its partnerships have added tremendous value and unique opportunities for PEEC students to engage in engineering projects in the local community.

Engineering Projects in Community Service (EPICS)
The EPICS is a new program being created at SDSMT, through an NSF grant (1525831), that will offer more opportunities for OLC and SDSMT to partner on engineering curriculum and service projects throughout the academic year. The EPICS is modeled after the flagship EPICS program at Purdue University, but it is a first collaboration with a tribal college. The EPICS programs feature student-led, multidisciplinary, vertically-integrated projects that meet the needs of long-term community partners. Research shows that EPICS programs have the ability to attract underrepresented students. For example, at Purdue University in 2014, 29.9 percent of the participants were female and 46.7 percent of the participants were non-Caucasian (Matusovich et al., 2013). Enhancing the objectives of the South Dakota PEEC to integrate projects that meet the needs of the reservation, one of the goals of the new EPICS program is to have 50 percent of the projects meet the needs of NA communities. The SDSMT EPICS program will offer opportunities for project teams to include OLC students, who will be enrolled for course credits at SDSMT, but they will have the opportunity to participate through distance classroom lectures and project team meetings.

Other grants
Through the opportunities provided by PEEC, several other related projects have developed. Those include a South Dakota NSF EPSCoR R2 T1 “Beyond 2015” grant and its successor “2020 Vision,” two USDA NIFA (United States Department of Agriculture, National Institute of Food and Agriculture) Tribal College Equity grants, a fourth NSF TCUP (TCUP IV “*Woksape*”) grant in 2016, a second NSF PEEC award in 2016, two SD Department of Fish and Wildlife grants (ornate box turtle ecology and *Bison* genetics), an NSF Research Initiation Grant (RIG) to OLC faculty member Alessandra Higa (ornate box turtle genomics), and two successive years of

K-12 outreach from the American Honda Foundation ("*Woniya Sa*"). What all of these grants have in common is that they build on ideas first articulated for the SD PEEC.

Because of this unexpected synergy between grants (which was the goal of OLC's NSF TCUP III grant, "Creating Synergy in Science and Education" or "*Yuowanca*"), the methods and goals articulated for the SD PEEC are being applied to all disciplines, degrees, and programs within OLC's Math, Science, and Technology (MST) Department.

CONCLUSION

Synergistic partnerships and projects have had a profound impact on both the successes of the South Dakota PEEC program's students and capacity-building. Through extensive collaborations, students have been involved in numerous real-life projects with real benefits to their communities, enhancing their interests in STEM professions.

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Student composition in this pre-engineering Chemistry class at the College of Menominee Nation (CMN) is typical of gender diversity in CMN's engineering programs. Women comprise half of those enrolled in the pre-engineering programs. (Photo credit: CMN by DKakkak)

17.

Promoting Native women: An underutilized resource

Joanita Kant (SD), Alaina Hanks (SD), Robert Pieri (ND), and Jennifer Benning (SD)

INTRODUCTION

Within PEEC, whether in Hawai‘i, North Dakota, South Dakota, or Wisconsin, Native women may represent an underutilized resource. Historically, women have often served as important leaders, regardless of whether Native Hawaiians (NHs) or Native Americans (NAs) traced their lineage through the male or female line or some combination of both, and regardless of which gender held primary power within such lineage systems. Examples of such women leaders in Hawai‘i include the last monarch of the Kingdom of Hawai‘i, Queen Lili‘uokalani, and the last heir apparent, Bernice Pauahi, her foster sister. In the modern era, a more recent example includes woman leaders with NH ancestry working to bring engineering to NHs within PEEC. The latter have been a driving force behind sharing information through this book.

At North Dakota’s tribal colleges, Ressler (2008) has noted that women have played key leadership roles, recognizing Native women as gatekeepers of their nations’ stories and traditions. Concerning tribal colleges, Sorenson (2015) reported that more than half of tribal college presidents are women. In Wisconsin, the College of Menominee Nation (CMN) was founded by a woman, S. Verna Fowler. The current chair of the Menominee Tribe is a woman, as was a recent predecessor. When the Menominee Tribe lost their federal status in the 1950’s, women led the efforts to regain their federal recognition. At Oglala Lakota College, the central tribal college in the South Dakota PEEC, their Vice-President for Instruction, is a woman.

With a tradition of such strong leaders as role models, some PEEC participants ask the question: “Could we have done more to encourage Native women to take up engineering?”

ROLE MODELS, MENTORS, AND INVOLVING WOMEN WHO ARE ENGINEERS

In order to effectively increase the numbers of NH and NA women in engineering fields, it is important to recognize the value of role models and mentors. For PEECs, having more women in leadership roles as Principal Investigators (PIs) on the projects may have helped to increase the numbers of female engineers, an opinion expressed by two South Dakota PEEC leaders who are women engineers.

Gender inadvertently played a role in PEEC at College of Menominee Nation (CMN) in Wisconsin. For example, when their PEEC was headed by a man, four out of five PEEC students were male; when PEEC leadership transitioned to women, 12 of 16 students were female according to CMN PI Diana Morris. It is also important for women to see other women, who are actually engineers as role models, a rare sight at many PEEC schools. While it may be beneficial for PEEC students to see women in such roles, there may be more opportunities for PEECs to create conditions to promote Native women's success in engineering by first turning attention to the topic.

STRATEGIES FOR RECRUITING MORE WOMEN TO ENGINEERING

Whether or not they are NH or NA, recruiting and retaining women in STEM fields, with the exception of Biological Sciences, remains an issue for most of those fields on the way to gender parity. Of prime importance is recognition of the problem and willingness to seek solutions through interventions. Chachra defined some embedded aspects of the problem as follows.

> *. . . [W]omen in engineering are told, in a host of small and subtle ways that engineering is not for them. We see the effects of this in lower efficacy, higher dropout rates, and lower satisfaction in engineering. A vocabulary has developed that allows us to describe and research these effects: privilege, gender schemas, micro-messaging. It allows us to realize that we all have unconscious biases, inculcated in us via a culture that perpetuates them so effectively that they are almost invisible.* (2014, p. 21)

Some solutions may include co-curricular interventions that encourage "self-efficacy," a term initiated by Albert Bandura, but noted by Lourens as follows.

> *Increased self-efficacy relates to positive outcomes for women studying and working in traditionally male-dominated fields such as engineering, science, and technology.* (2014, p. 13)

Chachra (2015, p. 21), also noted the importance of experiences that create "self-efficacy" (feelings of competence at certain tasks) for women engineering students. In addition, other solutions might include experiences that promote self-confidence, “mastery experiences” (feelings of competence for a certain skill set), vicarious experiences (observing others succeed with certain skills), and “social affirmation” (praise from others about competency in certain skills). In addition, Chachra noted that women may lack role models and may face “negation” factors.

Other solutions may include programs for women that increase their confidence in mathematics, particularly calculus. Ellis and others reported the key role of calculus, in particular, as follows:

> *Certainly it is preferable to increase girl’s and women’s interest in STEM at all life stages, but . . . only targeting efforts at college calculus and beyond would increase the number of women entering the STEM workforce by 75%.* (2016, n.p.)

As noted in at least one instance in PEEC, the impact of Calculus I can be the difference between a student continuing an engineering program or alternatively deciding to go into construction management. Calculus has a reputation as a “gatekeeper” course. Kant and others (2015) reported that lack of preparedness in K-12 mathematics, in general, was often perceived as a barrier to engineering studies by NAs of prime college age in South Dakota.

PEEC programs can actively promote gender parity by seeking targeted interventions to improve women’s self confidence in an engineering profession that is dominated by men. The PEECs may consider models used by others. An example was reported by Lourens (2014), where their program offered opportunities for women in special mentorships with publishing opportunities to increase women engineering students’ confidence and feelings of belonging in engineering. Helping NH and NA women engineering students to experience success in relevant skills and skill sets, and connecting them with mentors and supporting peers who understand that engineering is for women, may help to improve their numbers. Another example of a targeted intervention is helping women with personal development skills such as leadership, motivation, networking, and teamwork (Lourens, 2014). The inclusion of more women engineers in the profession will bring a more diverse perspective to engineering.

Robert Pieri, NDSU’s PEEC PI and Professor of Mechanical Engineering, reported that there may be an opportunity to work in conjunction with nursing programs to support PEEC activities. A comparison of curriculum between the two career fields of engineering and nursing highlights the similarities in the supporting structure in particular for “science for the service to humanity/ society” that is the driving function for both careers. For example, personal experience for co-author Pieri has illustrated a synergy that can exist between students considering the nursing profession and exploration of biomedical engineering. The opportunity stems from the students’ personal approach to providing healthcare. That is to say that if the student has a personal one-to-one opportunity to provide aid to a family member or close friend, then the traditional nursing career has a particular appeal. However, if the interest stems from a more generalized desire to “help people” then providing information about the opportunities to do so through biomedical engineering can broaden the students’ thinking about that career field.

The above is nicely illustrated by the National Academy of Engineering’s (NAE’s) Grand Challenges which describes fourteen areas of work that provide opportunity for the general betterment of society. Included in these areas are: Provide Access to Clean Water, Advanced Health Informatics, Engineer Better Medicines, Reverse-Engineer the Brain, Advanced Personalized Learning and Engineer the Tools of Scientific Discovery. These named areas, either directly or with some explanation, can utilize the same student motivation as demonstrated in a nursing career. The emphasis moves from “one-to-one” toward societal impact with the biomedical engineering selection. Supporting this opportunity for biomedical engineering should also include a better personalization of the engineering education environment both from the point of view of participants in the education, as well as the subject of the education. There is no need to recruit these additional students and then to disillusion them by the way teachers and faculty go about their preparation.

ENGINEERING’S IMAGE AS A CARING PROFESSION

Recent research (Kant, et al., 2015) among NAs in South Dakota indicates that many NAs do not perceive engineering as a caring profession, a necessary attribute in order to draw more NAs and women to the field. Matusovich and others (2013) reported that forms of experiential learning, such as service learning, show potential for increasing the numbers of women in engineering because such practices are perceived as caring about community. Kant and others (2015 and 2016) reported that projects that focus on service learning, tribal relevancy, and engineering as a subject that is suitable for girls and women, may be important factors in influencing females to study STEM. Experiential learning and a hybridized form of service learning were integral components of PEEC projects in South Dakota through collaborations with established community organizations, especially on-going tribal projects that were identified as needs by the community (Kant, et al., 2014).

Robert Pieri, PI for the NDSU PEEC, reported that he has success in recruiting NA women to engineering, in some cases perhaps because they were previously interested in studying to be nurses, one of the ultimate caring professions. The PI for the CMN PEEC in Wisconsin, Diana Morris, noted that in order to bring women into the PEEC program, projects were focused on helping activities and connecting to the community. The CMN successfully used such a “women-centered” approach in attracting both men and women to engineering.

CONCLUSIONS

Recognizing that Native Hawaiian and Native American women have demonstrated great leadership potential through time, PEEC may be improved by turning more attention to women’s issues that may help them to find their way in the male-dominated field of engineering. Women as advocates, role models, mentors, and engineers have been important for student success in PEEC, including highly capable women within the NSF, such as Lura Chase, Rebecca Bates, and Donna Riley, to name a few. Implementing practices that build women students’ self-confidence in engineering skills, especially in their ability to master calculus, reportedly demonstrate significant potential. The PEEC may capitalize on promoting engineering as a “caring profession,” as well as trying a “women-centered” approach to attract more women engineers. Those may be approaches that help PEEC leaders to recruit and retain both women and men in engineering studies and careers.

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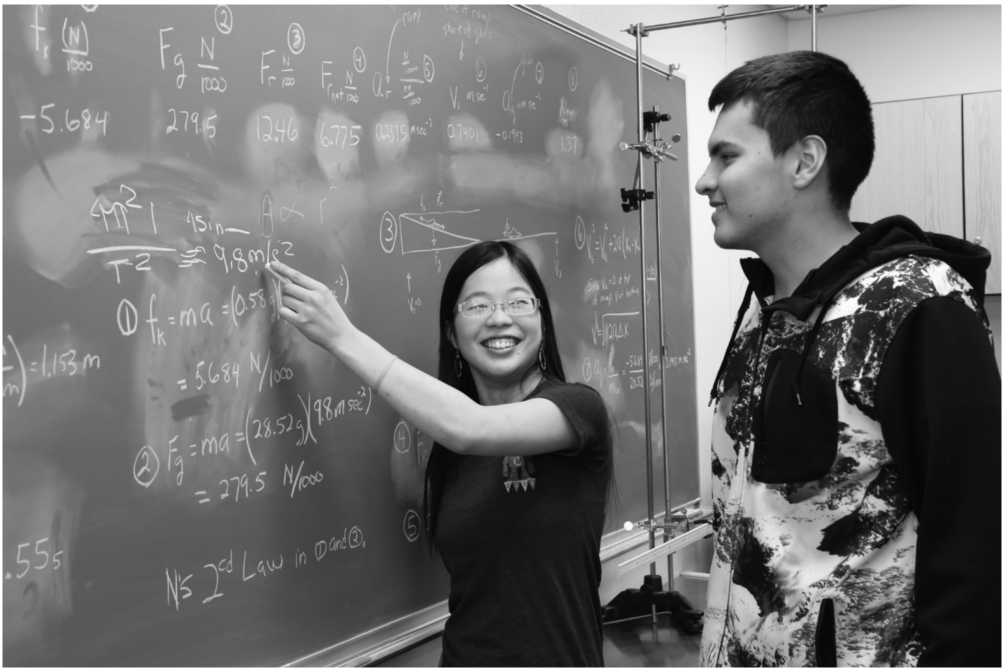

College of Menominee Nation PEEC students Chelsey LaTender and Taylor Oudenhoven. (Photo credit: CMN by DKakkak)

18. Succeeding with students: PEEC student stories

G. Padmanabhan (ND), Hannah Aldridge (HI), Alaina Hanks (SD student), Wiyaka His Horse Is Thunder (SD student), Gabriel Brien (ND student), Ryan Brown (ND student), Teri Allery (ND student), Daniel Johns (SD student), Kai Jones (HI student), Nathan Park (HI student), Kimberlynn Cameron (SD student), Chelsey LaTender (WI student), Taylor Oudenhoven (WI student), and Sarah Brei (WI student)

INTRODUCTION

All PEEC programs are student-centered. Within a culturally adaptive environment, Native Hawaiian (NH) and Native American (NA) students are motivated, nurtured, and encouraged to dream big and to pursue education in STEM disciplines. The most important element of the PEEC programs is the interaction of Native high school, Native college, mainstream university, and engineering profession stakeholders to facilitate the recruitment, education, and support of Native students to acquire the skills to enter the engineering profession or to contribute in some other fashion to their communities and the nation. In order to facilitate a smooth journey for NH and NA students to and through an engineering program, it is helpful to have adequate academic and cultural support structures in place in Native-serving colleges and universities. Whenever possible, pedagogies of experiential and service learning were employed using projects within the local community for NA students (Pieri, et al., 2013; Pyatt, et al., 2015; Sawyer, et al., 2014; & Tinant, et al., 2014). Hands-on activities were employed as much as possible in lesson plans for NAs in the North Dakota (ND) PEEC (Lin, et al., 2007 & Padmanabhan, et al., 2013). Across many of the PEEC programs, common elements built into student instruction and activities were community-relevance, cultural sensitivity and support, and experiential learning (Benning, et al., 2014a; Benning, et al. 2014b; Kant, et al., 2014; & LaVallie, et al., 2014)

The success or failure of such programs is directly related to the quality of students' experiences with the program, leading to student retention and graduation. The following are some narratives in their own words of students' experiences within PEEC programs in Hawai'i, North Dakota, South Dakota, and Wisconsin.

PEEC STUDENT STORIES

Hawai'i PEEC

In the Hawai'i PEEC, Maui students explored electronics engineering technology through a variety of hands-on activities. Students were required to present their project progress and engineering calculations to their peers. The emphasis was on exposure to technology with limited engineering mathematics to support their projects. Students prepared posters and practiced describing their projects in preparation for the Indigenous Knowledge in Engineering ('IKE) symposium. Students participated in a poster session and discussed their summer projects and presented their finished work, along with any research and/or calculations that supported the project.

Kai Jones (Transferred to UH at Mānoa from Leeward Community College, graduated with an AS in Natural Science from Leeward, 2016 Spring)

I first heard about the 'IKE program in high school from a flier. Immediately excited, I told some friends about it, and we applied for the Summer Engineering Experience I (SEE I.) Fast forward a couple months, and I got a call saying I was accepted. I was fortunate enough to receive a free education, an amazing experience, and many opportunities. Because of 'IKE, I am an aspiring mechanical engineer attending the University of Hawai'i at Mānoa.

Being accepted into a program like this was a big deal for me. A college credit math course and hands-on learning experience FOR FREE? The deal was too good to pass up. 'IKE funded everything necessary such as a laptop to do online work, textbooks, food, and if transportation was an issue, a bus pass. Luckily for me, I was able to use the same math textbook I received in SEE I for two other math courses in college. Every morning we had class for about two hours, followed by lunch, then our kinesthetic activities. It was educational both academically and culturally. Before the start, and at the end, of every day, we sang a traditional Hawaiian chant for our knowledge and success in learning. We also had field trips to learn about specific areas of work in the STEM fields and to do environmental activities. Finally, we had a symposium where we formed groups to present small research projects and to discuss what we learned over the summer. After SEE I, some of us were able to attend a summer camp where we reunited and had some fun.

In addition to SEE I, ‘IKE gave me other opportunities for experience. The summer after SEE I, I applied for Undergraduate Research Experience (URE) at Leeward Community College, where I worked with Professor Bryson Padasao and with four other students in a research project. We conducted research on triboelectric and piezoelectric materials to gather data on how much energy those methods produce. The eventual goal was to make self-sustaining biosensor clothing to wear. This research experience was also presented at the ‘IKE symposium for that year.

All in all, I’m extremely grateful to be a part of such a fantastic program. It helped me to take a step forward in my college courses and hands-on activities to make connections with people, and to form friendships with others who will be attending the same schools. I hope this program continues to help other students coming out of high school and to propel them forward in their future goals of working in the STEM fields.

Nathan Park (Transferred to UH at Mānoa from Leeward Community College, currently finishing a BS in Electrical Engineering)

I have been in the ‘IKE program for two years. I first began ‘IKE in the summer of 2015, where I did the SEE2 program in Maui. It consisted of three engineering related projects and a free Calculus 2 course that I had to complete in 6 weeks. It pushed my learning limits and that helped to accelerate my progress in pre-engineering. I was behind in my degree, since I switched from Agricultural Science to Engineering. Now I am not as far behind. The projects gave me good hands-on experience while learning, and it is exposing me to Hawaiian culture.

After the summer, I began working at my school’s Hālau as a STEM tutor. Through this job, I was able to support fellow students and keep my mind fresh about what I’ve learned in the past. STEM education is my passion although I struggled in math and science, but through hard work and help from good tutors and instructors, I have improved greatly. This experience has helped me to develop and fulfill that passion. Overall, the experience has significantly enhanced my education at Leeward CC.

North Dakota PEEC

The annual two-week summer camp held at NDSU, one of the major components of the ND PEEC program, included several student activities such as three-credit courses (Surveying, Dynamics, Thermodynamics, and Digital Systems), math review, visits to various science and engineering laboratories and to industrial and utility plants, along with cultural activities, and research-using scenarios, among others (Padmanabhan, et al., 2013;

& Pieri, et al., 2013). A sample schedule of the 2013 camp is included in the color photo section of this book.

Gabriel Brien (Transferred from Turtle Mountain Community College, graduated with a BS in Civil Engineering, NDSU, 2016 Spring)

The PEEC has been present in North Dakota for the last six years, and I have had the privilege of taking part in the PEEC program for five years, starting as a senior in high school, and progressing on to where I am today, as a graduating senior at NDSU. Upon graduation, I will have completed a BS in Civil Engineering, and I plan to further my studies at the Massachusetts Institute of Technology, where I will pursue an ME degree.

Up to this point in my academic career, PEEC and the people associated with it have been the most influential factors on my higher education experience.

My first experience with the program was a class I took in my senior year of high school with Dr. Robert Pieri. The class was called Engineering 115 and was billed as an introductory class to the collegiate engineering experience. It was through that class that I began a journey, which I am still on, to understand what an engineer is and what an engineer is supposed to do. The great aspect about the class was that it was taught in a fashion that really reflected a personalized approach to education, and an understanding of my personal background in a reservation community. There was never an effort to minimize me or the other students in the course, which was a pivotal point in making the class a comfortable environment in which to pursue knowledge.

As time progressed, I went through a PEEC summer program in addition to my freshman year of college at Turtle Mountain Community College, where all engineering-related courses were taught by PEEC instructors. And what was great, was that the same personal education experience and understanding was maintained and kept in a way that has not been emulated in any other aspect of my education. Whether it was an instructor who was willing to skype for help with homework problems, or a mentor willing to take time to chat, there was always a full network of support that really imbued me with the feeling that someone was there, and that they cared.

Once I transitioned from the community college experience to NDSU, the structure of my involvement with PEEC changed as well, but I was able to maintain certain elements, and there were new avenues that opened.

In my new surroundings, I entered a more mentor-oriented role and had the opportunity to give back to PEEC not only through participation in PEEC-sponsored study groups, but also by acting as a mentor and instructor in the same PEEC summer camp where I had benefitted only a short time earlier. This allowed me to garner new perspectives and new looks at familiar experiences, and I was able, simultaneously, to cultivate a new found enjoyment for teaching that allowed personal betterment. It was an excellent continuing education opportunity for me, and one I would not have had in the absence of PEEC.

Now, as I conclude my undergraduate career and move ahead to a graduate experience, I can honestly say that I would not be where I am today, poised to enter one of the most prestigious engineering schools in the country, had it not been for PEEC and the people who run it. Whether it was through the financial support, or more importantly, just having someone to talk to, PEEC was the constant that I could rely upon as I strove to become the best engineer possible.

Moreover, I think that the opportunity is there for continued experiences for students like me. What the PEEC program provides in a link; it is the ever vital connection with the understanding that students need to survive in a challenging collegiate experience. The issue with the tribal college to four-year college transition has very little to do with student abilities and much more with student knowledge of their new surroundings. More often than not, students do not grasp what they need to do to succeed. Nor do they know what to do when they fail. That is why a program like PEEC is so vital. The familiar faces in PEEC provide support for students and show them how to succeed, and then it calms them when they fail. It really is that simple. As a great man once said, “You can do it; we can help.”

The PEEC provides the financial, academic, and emotional support that Native American students need to survive, and it does so in a way that understands where they come from. The PEEC is providing Indian Country with badly needed engineers. I ask you, if PEEC doesn’t do it, then who will?

From the start of my journey in small town North Dakota, to my newest destination in the heart of the Boston metro, PEEC and the people who are a part of it, have been there and will continue to be there, helping me every step of the way.

Ryan Brown (Transferred from Cankdeska Cikana Community College, graduated with a BS in Civil Engineering, NDSU, 2015 Fall)

I would like to start off by thanking everyone who made the PEEC program possible. Overall, it was truly an amazing experience, and I'm glad I was able to be a participant in the program. My experience first started at Cankdeska Cikana Community College in Fort Totten, ND. Coming out of high school, I was unsure of what I wanted to do. My first thought was construction building or maybe just general studies. I was introduced to the PEEC program the summer after I graduated high school by a professor from NDSU, and I decided to give it a shot.

During my two years at CCCC, the PEEC program offered not only courses that our tribal college didn't offer, but it also offered the financial resources to allow students to focus on school work. This allowed the student to not have to work full or part time. In my case, it allowed me to take my first two years of engineering at my local tribal college. The program was good at hiring instructors who did a great job with our courses and in interacting with students. It was a lot easier to learn in the atmosphere they provided, because it was a small class, and all instructors understood our background and culture. In most cases, they could relate to us as Native American students, and I felt comfortable and welcome in their classrooms.

The PEEC offered two, two-week summer courses on the NDSU campus, while we were still attending our local tribal colleges. The first year we learned surveying, and the second year, thermodynamics. This allowed students in the program to earn credit for a course, receive funding to pay for tuition, and live the life of a college student in the dorms. The summer courses definitely showed how the life of a college student would be on a university campus like NDSU. It was very beneficial for me, because I got to know NDSU campus prior to transferring.

The PEEC is set up in collaboration with NDSU and the tribal colleges of ND. So I knew when starting the program that I was committed to transferring to NDSU after I graduated from CCCC. The process of transferring to the NDSU Engineering program was relatively easy. I say this because NDSU was aware of the PEEC program, and they understood the needs of Native American students in the STEM fields, and they supported us all the way through the process. As I rode my bicycle to class for the first time, it felt like I had already been attending school there. I was able to locate my classroom, thanks to the summer courses, and it made my first few weeks easier. In my case, there were a couple of courses that did not transfer from our local tribal colleges, but we were able to work with our department and registration office to get those courses in the NDSU system.

Switching from a small class to a big class was a little different for us PEEC students, but I still felt that instructors in the Civil Engineering Department understood where I came from and my background. They were almost happy that I, as a Native American, was part of their classroom. It once again made me feel welcome and comfortable. My favorite part, while attending NDSU, was being able to work alongside fellow Native American students from other tribes, students who were pursing the same dream of becoming an engineer. It allowed us to become one whole family, and we supported one another.

I am the first PEEC Program graduate in ND. I hope I'm inspiring younger PEEC students to continue their dreams and plans of becoming an engineer. We have two more students this semester, and it is so great to hear that we have success stories out of this program. Being out of college, I can reflect back on what I have been through the past 4.5 years. One of the things that stands out the most for me with the PEEC program is the university's ability to work with the tribal colleges to make all this possible. They supported and recognized our local tribal colleges in many ways. It was great to see how NDSU with 14,000+ students could work with a community college of 240 students.

I would like to end this letter by saying, thanks again, for all my fellow classmates, instructors, advisors, PEEC classmates, Cankdeska Cikana Community College, and North Dakota State University for supporting me and my dream to become a Native American Engineer. As my tribe's first enrolled Engineer, I hope to inspire many more in the future.

Teri Allery (Transferred from Turtle Mountain Community College, graduated with a BS in Civil Engineering, NDSU, 2016 Spring)

I am an enrolled member of the Turtle Mountain Band of Chippewa and am from Belcourt, ND, on the Turtle Mountain Band of Chippewa Reservation.

What does PEEC (Pre-Engineering Education Collaboration) mean to me? Well, I would have to say "everything," because I would not be where I am today without PEEC. I graduated this spring semester of 2016 at NDSU with a BS in Civil Engineering. With the help of the PEEC program this was possible not only because they help with funding, but because there were teachers, mentors, advisors, and other PEEC students who helped me along my journey in the program.

After a few short months of being in the program, I realized that these people were not just going to be my teachers, advisors, mentors, and fellow students, but they were going to become my family-in-fact. In that little time, they had already become family. Some may not know that for Native Americans family is everything to us, whether we are blood related or not.

My journey in the PEEC program started at Turtle Mountain Community College (TMCC). I attended TMCC for two years. That is where I and my family started the journey of becoming engineers together. It was a great experience that prepared us for university life. If I or any of the other students were having difficulty in our classes, we would all sit down and try to help each other. Times were tough occasionally, when we couldn't figure out the answer. That's when we truly felt like sisters and brothers, because tempers would flare often, but we would grind through and eventually solve the problem whether it were statics, basic linear algebra, or any other classes we attended.

I should also mention that we had extended family out there. We would attend classes with a few other students from tribal colleges in the area such as Cankdeska Cikana Community College, Fort Berthold Community College, and Sitting Bull Community College. At our occasional meetings, we would all sit around and visit to get to know one another and also to get pointers in the classes we were taking. We always stuck together and never gave up.

In the summers, we would attend NDSU for a PEEC camp where we would earn full college credits in 12 days for whichever class we took. This was tough, but we succeeded, and it prepared us for campus life, once we transferred.

After two years with TMCC and two PEEC summer camps, I continued on to NDSU. I was pretty scared at first, going to the big University, even though they had been preparing us. Once I got there, I realized that it wasn't so bad. Actually it wasn't bad at all. It was great, and my family grew larger, because now we had several students from each of the tribal colleges, which just meant that we had that much more help. We would have study sessions for two to three hours, two days every week, where we all got together and did homework. It couldn't have done it without my brothers and sisters.

Now enough talk about us students. Although we worked hard, we couldn't have done it without our advisors, staff, and faculty. There were a lot of times that I felt like giving up, but I would meet with one of my advisors such as

Dr. Padmanabhan, and they would sit and listen and give me a pep talk. I assure you that anything you may ever need, you can go to these awesome people, and they will do anything in their power to help you get through this program but, you have to want it, because it isn't going to be handed to you. It's a lot of hard work, but at the end, when you're walking across that stage, it is all worth every tear you may have shed or every temper tantrum you may have thrown when you wanted to give up.

Every person in this program was very important to me, whether student staff or faculty. I have to give an extra shout out to my advisor at NDSU, Dr. Bob Pieri, for always giving me pep talks to make sure I stayed focused on the goal. In his great words, "Get the degree, get the job, get the life," he reminded us that if you stick to these words, you will go places. THANK YOU, Dr.Bob, for everything. One other person I have to say thank you to is my advisor at TMCC, Ann Vallie. I would not be where I am today, if it were not for her at both TMCC and NDSU.   Thank you for all the confidence you have in us students. This is coming from someone who had no confidence before I started this program. You gave me that urge to want to better myself and to have the confidence to succeed in this program, and life in general, by always showing your compassion for this program and your students. For that I am forever grateful!

If I can give any advice to anyone who is interested in this program, I would say, "Go for it." Anything is possible when you put your mind to it. I took many years off from school and came back at the age of 27. Here I am now, a 33 year old graduate, and now a Civil Engineer. If I can do it, so can you. Study hard, stay focused, and don't be afraid to ask questions because no question is a dumb question! Thank You PEEC program for everything. I am grateful for all you have done for me, and I will never forget where I came from.

Brittany Bruce and Connie Greene, Nueta Hidatsa Sahnish Community College (NHSCC): Student reactions to the ND PEEC

The ND PEEC collaborative uses an Interactive Video Network (IVN) to link all of the site classrooms to each other. Nueta Hidatsa Sahnish College student Brittany Bruce stated that "attending video classes is weird at first, but it's wonderful that we get to connect with other people this way, and it gives me the opportunity to enroll in a program that I otherwise would not be able to do because of my family obligations."

Connie Greene enrolled in the program in order to increase her skills beyond entry-level positions. She worked at Northrup Grumman (makers of parts for fighter jets under military contract) for nearly twenty years – but exclusively as a laborer. “I’ve always wanted to be part of their production team,” she said. “It just never worked out.” But with an engineering degree, she will soon have the credential needed to move from laborer to designer – or pursue new opportunities elsewhere (Boyer, 2015).

South Dakota PEEC

Daniel Johns (South Dakota State University, B.S. Electronics Engineering Technology, 2010)

I am from Sacaton, AZ, and I am an enrolled member of the Gila River Indian Community. While I was attending South Dakota State University (SDSU) as a graduate student in the College of Engineering, I had the opportunity to participate in a PEEC internship that was a collaborative experiential-learning exercise between SDSU, SDSMT, and Oglala Lakota College (OLC). The internship was in a related field of study, but it did interest me; so I jumped at the chance to be a part of it. I was the lone graduate student *i*ntern from SDSU in the program; so it was important for me to act professionally and to set a good example for my younger peers.

Given that the internship was only in a related field of study, I got to experience some things that I wouldn’t normally have been able to do. This was my first time doing fieldwork, and I got to participate in every aspect of it, from the sample collecting, to the lab processing and the data analysis. I thoroughly enjoyed this part of the internship. I have done lab work before, but it was not with samples that I, myself, had collected. It gave me a greater appreciation for the amount of effort that goes into that type of work. We were collecting samples from the White River in western South Dakota to detect the levels of selected heavy metals. Results indicated that concentrations of heavy metals were lower near the headwaters region of the river and higher near the confluence of the Missouri River.

During the internship, we stayed near Kyle, SD, on the Pine Ridge Reservation. It is always interesting to visit different reservations and to see the similarities/differences from the one where I originated. Since this was a collaborative exercise, I also got the chance to help with some of my fellow interns’ projects. There were projects from fish shocking, to using GIS, to plotting the locations of indigenous plants in the locale. All in all, the internship was a great experience, and I am very thankful for the opportunity to have been a part of it. Since the internship ended, I transferred to the University of Arizona where I earned an M.S. in Engineering Management.

Kimberlynn Cameron (Standing Rock Sioux Tribe,
M.S. Civil & Environmental Engineering Graduate Student,
BS Geological Engineering, August 2014,
South Dakota School of Mines and Technology)

During my second year of college, I needed to find a summer internship. I found that it was really hard to find anybody willing to hire a younger student, so I decided to find something within the college. Professor Foster Sawyer happened to have a position available within the PEEC program that was a potential fit for me, because I was an enrolled member of a tribe in South Dakota and a geological engineering student at the South Dakota School of Mines and Technology. The internship provided me an opportunity to obtain experience with a type of service learning based project designed to assist the Pine Ridge Indian Reservation communities with some of their everyday problems and issues that could potentially be solved with engineering-based solutions.

For the internship, I had to identify the watershed for the Pine Ridge Indian Reservation and create a watershed map using ArcGIS (Aeronautical Reconnaissance Coverage Geographic Information System). I also had the opportunity to learn how to survey. Because of PEEC, I had the experience necessary to intern with a mining company the following summer. Part of the reason I was selected for the internship position was because they saw my ability to work with an application a couple of years before I was supposed to take the related course, ultimately showing my versatility to tasks at hand and overall potential. I like to think of my time with PEEC as the beginning of a ripple effect. The experience and knowledge I gained led to internship after internship with various companies throughout my academic career, and that provided me with a diverse background in engineering.

At the end of my senior year, I was unable to take any internship opportunities because I had geological engineering field camp, leading me to intern with PEEC again. I assisted SDSMT's Dr. Jennifer Benning on indoor air quality studies for her collaborative project with Thunder Valley Community Development Corporation (CDC) and Native American Sustainable Housing Initiative (NASHI). Initially, I didn't know if I was going to learn anything more through the internship, because I thought that I had already reached my peak within PEEC. I assumed that the program was meant for undergraduate students who were in the beginning stages of their academic careers and who had never had an internship. However, PEEC continues to prove me and countless other people wrong because of how the program is structured.

While the program itself is designed to assist communities, it is also designed to ensure that students are getting the foundation they need to be able to continually progress both inside and outside the PEEC collaboration, regardless of educational background and level of expertise. The professionals within PEEC are very patient and ensure that their interns are advancing in their assigned projects, while at the same time moving at the student's own learning pace. The people involved give so much of their time that you sometimes wonder how many hours they actually have in their days. They really make themselves available, especially for the Native American students participating in the program. They take special interest, not just in a student's development for a summer, but throughout an entire semester and the semesters after that. From my experiences alone, Dr. Benning has taken me under her wing and provided tutelage, pushing me to become better each day. As long as a student is willing to take the extra step to say "I want this" and show effort, there is a substantial amount of support provided and the PEEC leaders are there for them 110 percent, if not more. As a Native American graduate student, I cannot thank the PEEC program enough for the opportunities and support provided to me. Without my time in the program, I can say with certainty that I would not be as successful as I am today.

Wisconsin PEEC: College of Menominee Nation (CMN)

Chelsey LaTender (Pre-Engineering Associate Degree program, College of Menominee Nation)

Engineering is a natural field for me because I like science and math, and I also like to learn how systems work and why they work.

It wasn't until I went to an engineering fair at the University of Wisconsin-Madison that my interest sparked in engineering as a career. The big university event was impressive, but the small tribal college I chose has been the right fit for me. My experience in the new engineering program here at the CMN has been wonderful, and it provided many opportunities that might not have been possible elsewhere for a recent high school graduate.

One of the best things about attending CMN has been being part of a cohort of friends who are in the same pre-engineering program. We have gone through all of the courses together, formed study groups, traveled and done internships together. If I am having a hard time, I know I can go to them to help me get through it or to give me advice on what I should do. We are a great support system for each in our academic journey. They have made my experience here at CMN very enjoyable.

There were struggles along the way, especially with my upper-level chemistry courses. But I was able to get the help I needed. The professor was willing to spend a little extra time to make sure that I understood the material, and my peers encouraged me along the way. I knew that all of them wanted to see me succeed, just as I wanted it for myself.

Among my special opportunities at the CMN has been an internship in solar energy research and outreach. During this internship, fellow students and I wrote a series of illustrated story books that described different engineering fields and renewable energies for school-age children. Our goal was to show how STEM careers can relate to the cultural values of American Indian children. It was a wonderful experience, because by figuring out how to communicate my ideas to a younger audience, I learned to think of engineering and STEM in a different way. It had the added value of teaching me to express my ideas in a different type of media, instead of using formulas and equations. Hopefully, it will encourage at least a few children to think about becoming STEM professionals.

Taylor Oudenhoven (Pre-Engineering Associate Degree program, College of Menominee Nation)

I am a member of the Oneida Tribe, now in my second year of the pre-engineering program at CMN. I chose the engineering program because I enjoy exploring how math and sciences apply to the real world and because I ultimately want to use what I learn to help improve or make a difference in my community.

I have had great opportunities throughout my first two semesters, including work as a student intern with the College's Solar Energy Research Institute. One of the most motivating experiences so far came in my first semester was when I had a glimpse into what it was like to work on an engineering design project. I enjoyed the challenge of trying to improve and/or redesign a product while incorporating ethics and sciences.

During my first and second semesters I worked with classmates on creating a two-part children's book series related to environmental engineering and renewable energy. Writing the books helped me to understand the importance of exposing children to the STEM fields at an early age and also provided me with a deeper understanding of alternative energy. The internship also gave me experience in time management, since it was often a struggle to balance life, schoolwork, and my responsibilities as an intern. Luckily, I've had supportive faculty, mentors, and peers along the way and have learned valuable life lessons from my internships.

My experience at CMN has been challenging, exciting, and very positive. The opportunities and resources that have been presented to me have been helpful and highly motivating. I am looking forward to the future, to meeting challenges, and to working towards my goal of improving the world we live in, starting with my community.

Sarah Brei (Pre-Engineering Associate Degree program, College of Menominee Nation)

Some people just know what they want to be when they grow up. For me, all I knew was what I was good at, so I traveled down the path toward a nursing career.

After successfully completing a CNA [Certified Nursing Assistant], I found that although nursing was something I could be quite good at, I had no desire to do it for the rest of my life. That's when I made the big change to engineering. I've grown to love all the aspects of engineering, and I feel the desire to make it a lifetime career.

I waited a while after graduating from high school before deciding to further my education. I also came to college as someone who has many obstacles at home, including special needs among my family members. My oldest daughter has Type One diabetes. My middle daughter is Autistic. I am providing care for an elderly aunt undergoing cancer treatment. But with the support of my husband, I have been able to keep chasing my goals and dreams. Meanwhile, my daughters see their mother work hard to achieve a better education and provide them with a better life.

Even though I wasn't a typical student, I felt very welcome when I began at the College of Menominee Nation (CMN). The CMN has a capacity for accepting all kinds of students. Traditional students, and non-traditional ones like me, are met with understanding, and they are provided guidance. If we need help, we can find tutors in all subjects in the Campus Commons.

I think all students at some point hit a wall and begin to think they cannot do it, cannot obtain a degree. This feeling certainly reared its ugly head in my dreams once or twice, but the professors at CMN always knew how to build me up and keep me focused on my ultimate goal. Also, because CMN offers paid internships, I have been able to earn money while broadening my resume. The added benefit is that these internships have provided me with irreplaceable work experience in my field, which is more than most regular jobs could offer. By challenging me every day, my internships are giving me a chance to prove that I am capable of having a career in a field that I love.

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A TMCC student monitoring gas levels in the basement of a home. (Photo credit: ND PEEC)

19.
Measuring outcomes

Suzette Burckhard (SD), G. Padmanabhan (ND), Joshua Kaakua (HI), John Rand (HI), J. Foster Sawyer (SD), and C. Jason Tinant (SD)

INTRODUCTION

The National Science Foundation (NSF) recognized the need to enhance the quality of science, technology, engineering and mathematics (STEM) instruction at Native Hawaiian-serving institutions and tribal colleges. As a result, NSF developed the Pre-Engineering Education Collaborative (PEEC) program to address specifically the need to provide a pathway for severely under-represented Native Hawaiians (NHs) and Native Americans (NAs) to earn engineering degrees. Each of the four collaboratives that developed from the original PEEC program (Hawaiʻi, North Dakota, South Dakota, and Wisconsin) addressed the program in different ways that were unique to their geographic and cultural surroundings. This chapter describes the outcomes that resulted from those activities.

HAWAIʻI OUTCOMES

The Hawaiʻi PEEC established a consortium led by University of Hawaiʻi - Kapiʻolani Community College (UH-KCC) that enhanced the transfer pipeline to increase participation of NH students pursuing Bachelor's degrees in Engineering. This collaboration engages five University of Hawaiʻi Community Colleges (Kapiʻolani, Honolulu, Leeward, Windward, and Maui), with the UH at Mānoa College of Engineering (UH-M COE), the only ABET-accredited engineering college in the state. The two main goals aimed to provide, 1) a quality Pre-Engineering Core Curriculum online and, 2) a community of practice in Engineering, engaging NH students in Summer Bridge programs, Undergraduate Research Experiences (URE) and mentoring activities within the UH System and with community partners.

To date, PEEC has implemented a shared 39-credit pre-engineering curriculum across six campuses with 85 percent of the curriculum offered online. In addition, all community college PEEC partners have institutionalized a two-year Associate in Science in Natural Science (ASNS) with a concentration in Engineering, that provides students with a clear pathway to the UH-M COE from all UH community colleges in the state, including campuses on Oʻahu, Maui, and Kauaʻi, although the latter did not participate in PEEC. As a result, a memorandum of agreement was signed between the UH-M COE and all community colleges in the UH system that streamlines the transfer process for all UH students progressing from two-year to four-year institutions in Engineering.

The PEEC efforts supported 261 participants in Summer Bridge programs, and 131 participants in Undergraduate Research in Engineering (URE) and mentoring activities. PEEC has directly engaged over 400 students including 106 still enrolled in community colleges, 110 who have earned Associate degrees, 184 who have transferred to the four-year University (155 who are still pursuing Bachelor of Science degrees in Engineering and 29 who are pursuing STEM majors other than Engineering), and 60 students who have completed a Bachelor’s degree from the UH-M COE.

NORTH DAKOTA OUTCOMES

The overarching goal of the North Dakota (ND) PEEC project was to support a vision of expanded life choices for reservation residents that could provide more technical competency for tribal decision-making, infrastructure improvement, and the opportunity for personal and tribal advancement without compromising cultural heritage. The ND PEEC was successful in accomplishing the objectives it set forth for its first phase, and they continue the effort in the second phase to move forward in reaching the overall goal. Outcomes of the first phase are as follows.

The ND PEEC Phase-1 has produced three NA Civil Engineering graduates. The first graduate from Phase-1 is currently employed in his tribal planning department and one of their projects includes renovating 20 on-reservation homes, an obvious impact on his local community. As mentioned in a previous chapter of the book, one of the Phase-1 participants accepted a graduate student position at Massachusetts Institute of Technology (MIT) to continue his studies. Of the three Phase-1participants, one is female, a promising development when one considers that the national graduation rate for women in Engineering is about 18.6 percent. During the ND PEEC Phase-1 operation, more than twelve students have made the decision to move beyond their local tribal college to a mainstream institution. These are individuals who have decided to move forward in their educations after having overcome cultural concerns about off-reservation education in order to advance to the next level of opportunity. The ND PEEC team hopes that by having these diverse educational experiences, students will better appreciate and understand how to grasp and engage in more diverse opportunities within their reservation communities.

The ND PEEC was able to impact and affect half a dozen or more NA graduate students in their pursuit of advanced degrees. This was encouraged as a result of the graduate students' employment as mentors for PEEC Summer Camps or cohort study sessions at NDSU. These activities allowed some graduate students to experience the satisfaction of aiding in the educational development of people from similar backgrounds. Some of these students are still pursuing their advanced degrees, while others have earned their Master's degrees or Ph.D.'s and have gone on to positions in industry or teaching, respectively.

Besides impacts to the students within the PEEC program, each of the collaborating institutions has demonstrated some aspect of change as a result. For example, a recent 3-D printing effort, at some Tribal Colleges and Universities (TCUs) in this collaborative, has benefited from student and instructional resources developed because of the PEEC program.

The ND PEEC also conceived and developed a New Hybrid Distance Learning Model (NHDLM) to enhance the NA student engineering educational experience and engagement. The NHDLM is basically a curriculum operation that took advantage of the synergistic effects of combining traditional small class education at a tribal two-year institution, Interactive Video Network (IVN) distance education classes and periodic face-to-face instructor-student interaction within the context of crosstalk between the instructors of different classes at different locations. Plans are in place to test this model in Phase-2 ND PEEC.

The program, as it has functioned for the last five years, used a series of cohorts and advisory boards to attract and support the students as they progressed through the Engineering curriculum in different institutions eventually transferring to the mainstream school. The Phase 1 experience has demonstrated to the program leadership that it is not a simple process for any student to complete courses at a tribal college and then completely change their learning environment and habits to what is effective at the mainstream institution, while expecting the same success as before. Adaptations must be made.

SOUTH DAKOTA OUTCOMES

Oglala Lakota College (OLC) in South Dakota (SD) proposed to extend and enhance its capability to deliver the first two years of a Bachelor of Science degree program in Engineering. This capability was established in collaboration with the Jerome J. Lohr College of Engineering at South Dakota State University (SDSU), and the College of Engineering at South Dakota School of Mines and Technology (SDSMT). The program was called OSSPEEC (Oglala Lakota College, South Dakota State University, South Dakota School of Mines and Technology Pre-Engineering Education Collaborative). The project established collaborative offerings of gateway and bottleneck courses that occur in the first two years of Engineering curricula, coupled with on-reservation hands-on laboratory and service learning experiences on the Pine Ridge Reservation (PRR) that increased NA student interest, preparation, and experiences in Engineering. A major result of OSSPEEC was the establishment of a complete two-year pre-engineering curriculum at OLC, which enabled students to enter a four-year undergraduate engineering program at the junior level after completing the two-year curriculum at OLC.

Space at OLC campus was repurposed for Engineering classrooms, labs, and projects. Specialized equipment was acquired for use in teaching and summer research experiences. Eight gateway courses in Engineering were collaboratively developed and then offered at OLC, including courses in environmental engineering, surveying, statics, geology, materials, and computer aided design. Articulation agreements between the mainstream schools and OLC were approved and implemented. Vertical integration of pre-engineering and engineering capstone courses resulted in the development of community connections including the Oglala Sioux Tribe Environmental Protection Program (OST EPP), the Oglala Sioux Tribe Natural Resources Regulatory Agency (OST NRRA), Thunder Valley Community Development Corporation, Indian Health Service, the University of Colorado at Boulder/Native American Sustainable Housing, and the SDSMT Back to the Future Research Experience for Undergraduates program.

There were 66 students who took part in the OSSPEEC summer program from 2011 to 2015. These students included 65 percent Natives and 41 percent females. There were 17 graduate students and 49 undergraduate students who participated in the summer programs. Overall, students participating in the program earned 26 degrees, including three Ph.D. degrees, eight Master of Science degrees, thirteen Bachelor of Science degrees, and two Associate of Arts degrees.

Several OLC pre-engineering students who matriculated to Engineering programs have been awarded with summer support through REU programs at SDSMT. All three SDSMT students who bridged to SDSMT through the REU programs were awarded Udall Fellowships, three in the last three years. The first student who received a Udall Fellowship also was awarded a Truman Fellowship in 2015. He spent summer 2016 as an OSSPEEC participant, studying surface water/ ground water interactions under the direction of an OSSPEEC PI, J. Foster Sawyer of SDSMT.

These products and successes of the original OSSPEEC collaboration have influenced both SDSU and SDSMT administrators to strengthen their relationships with OLC, including scheduled and unscheduled visits, and collaboration on accreditation and faculty development. These activities also highlight how capacity building through OSSPEEC has increased OLC's ability to partner with mainstream Engineering universities, and has influenced institutional change at mainstream universities, leading to an increase in support for NA students seeking Engineering degrees.

WISCONSIN OUTCOMES

The College of Menominee Nation (CMN) PEEC along with the "Providing for the Education of American Indian Engineers" collaborative project, proposed the following objectives.

- To build CMN's capacity and infrastructure to sustain a Pre-engineering Associate Degree Program,
- To implement a pre-engineering program of distinction,
- By September 2015, to graduate at least twenty students from CMN's pre-engineering program and facilitate their transition to the University of Wisconsin at Madison's and the University of Wisconsin at Platteville's engineering programs.

An AA degree was developed and is progressing well. Three students have graduated during the PEEC project and 20 students (eleven females) are currently enrolled in the program.

The CMN's Assessment of Student Learning Committee is responsible for program review and assessment using established guidelines.
The membership of this committee consists of 80 percent faculty and representation from the Institutional Research Board. The first review is in the third year of the program and is followed by a repeating 5-year cycle of

reviews. Community involvement in the program is enhanced through the Curriculum Committee which includes one community member.

SUMMARY

Approximately 500 Native Hawaiian (NH) and Native American (NA) students were engaged by the four PEEC collaboratives over the five year course of the PEEC program as of the writing of this chapter. During this time, each PEEC has firmly established a pathway for NH and NA students to earn engineering degrees by offering courses on-site, in collaboration with mainstream universities, or in a hybrid or distance manner. Students participating in PEEC were consistently presented with interesting opportunities and experiences to enhance their preparation for and connection to engineering as a viable career path. Along the way, students have earned undergraduate and graduate degrees, completed relevant community projects, and have been awarded national honors for their efforts. As a result of the collaborations that were built between tribal colleges and mainstream engineering universities, those mainstream universities have been strongly influenced in how they offer engineering and in how they work with NH and NA students. Overall, the program has led to many successes and will have a lasting impact into the future, particularly since indigenous engineers are severely under-represented in the profession.

Hannan LaGarry of Oglala Lakota College explains to PEEC interns, the stratigraphy of Slim Butte on southwestern Pine Ridge Reservation, including how to identify uranium deposits among its colorful banded deposits. The reservation is a unique place for students to learn. It is a natural outdoor laboratory that includes spectacular buttes and badlands, amid rangelands bisected by rivers and streams. (Photo credit: Joanita Kant)

20.
Implementing through low-cost solutions

Joanita Kant (SD), Jennifer Benning (SD), Carol Davis (ND), and Lori Alfson (ND)

INTRODUCTION

All of the PEEC alliances are located in places that are particularly rich in natural resources suitable for teaching and learning STEM. By simply taking advantage of their natural environments, low cost solutions abound where PEECs can progress. The Hawaiian archipelago has hundreds of islands, a tropical climate, diverse plant life, volcanoes, and surrounding oceans. North Dakota has wide ranging resources from oil shale to the Missouri River. South Dakota's Pine Ridge Reservation includes parts of the Bad Lands, unique erosional remnants underlain by ancient ocean bottom strata, in a locale rich in heavy metals and bisected by two extensive river systems. Wisconsin's Menominee Indian Reservation includes a uniquely managed forest and is surrounded by dense forest.

All PEECs have available to them priceless "natural outdoor laboratories" that are suitable for teachers and students to thrive, even in situations where funding may sometimes be in short supply. Each place is also heir to the inspiring voices of Elders and their traditional stories about aboriginal ways of knowing that relate to what is now called STEM.

WHAT WE LEARNED

When natural outdoor laboratories are combined with local aboriginal values, students often relate better to STEM, persistence increases, and recruitment is easier in bringing pre-engineering to Natives. As examples, the following are stories for North Dakota (ND), South Dakota (SD), and Wisconsin (WI).

North Dakota
The geology of ND offers a wonderful opportunity for students to study the impact of the great salt sea that created the Williston Basin half a billion

years ago. About a million years ago, ND experienced the Ice Age, during which, several glacial sheets of ice covered parts of the state. As the ice melted, about 25,000 years ago, water from the melt and glacial drift formed much of the current landscape of the state, leaving many ice melt block lakes, rolling hills, and rich farm land.

The story of ND's human habitation begins with Native Americans (NAs) who resided there long before the arrival of Europeans. Native American pre-history, history, and traditions reveal their relationship with the environment. Their stories often include animals, water, and plants, and the stories provide an opportunity to study how tribes traditionally understand their place in the world, while leaving a relatively light footprint on their natural surroundings. North Dakota's Turtle Mountain Band of Chippewa have a story that explains the melting of the ice during the glacial period. The most unique feature of the science they practiced was their understanding that every living thing has a spirit. In part, this is what sets Native science apart from Western science.

There is evidence of indigenous scientists among Native Americans (NAs). For example, Pierre La Verendrye, probably the first white man to visit what later became known as ND and SD, documented in1738 that the Mandan grew corn that they traded for supplies with other tribes. Modern-day studies of corn among the Mandans revealed that they managed to cross pollinate corn plants to obtain larger plants in a less time, because of the short growing season in ND compared to the Southwest where corn was commonly grown.

Another feature in the early history of ND and SD was the large population of buffalo. Early explorers verified that there were millions of buffalo in the Dakotas. Tribes have many stories in their oral histories that detail the importance of buffalo in providing food, shelter, and bone tools. Thus, NA history and culture provides an opportunity for students to study many aspects of agriculture, construction, and other related topics that increase interest in STEM.

Ceremonies of NA tribes are often tied to nature. Tribes retain stories that relate to lightening, thunder, northern lights, wind, four directions, and other natural phenomena. Many are parts of tribal names that are given in naming ceremonies today, demonstrating the significance of environmental features to tribes.

To accommodate these tribal traditions, programs such as Nurturing American Tribal Undergraduate Research Education (NATURE) (Davis, 2008a), a collaboration between two ND mainstream universities and five ND tribal colleges, includes cultural teachers who lead teaching units. For example, at the beginning of each class, the cultural teacher introduces the lesson by relating a tribal story or tradition practiced by the tribe. This is followed by university/tribal college faculty, who expand the lesson into a current science, mathematics, or engineering activity. The purpose of combining traditional with modern lessons is to help students realize that they are part of a tribe that included indigenous vernacular scientists and engineers who contributed to tribal survival long before white contact.

Similarly, some North Dakota PEEC professors integrate culturally relevant project-based learning lessons into mathematics and engineering courses. The lessons provide real-life applications of those subjects. They make available interesting hands-on activities that promote creative problem solving, and that help students to relate to their own life and culture.

Some examples of lessons developed and integrated into mathematics courses such as college algebra, trigonometry, and calculus, are “Creation Stories,” “Flooded Lands,” “Earth Lodge Engineering,” “Blood Quantum Mathematics,” and “Fractionated Lands.” Furthermore, during ND PEEC Summer Camps at NDSU, students participated in a real-world engineering project scenario. Students were divided into two teams and were given a scenario based on real events that affect Native lands. Students developed an engineering project solution, documented in a written final report and communicated to an audience through the team’s oral presentation. Scenarios that students investigated have included “Flood Planning Study at Fort Peck,” “Explosion and Environmental Impact at Osage Reservation,” and “Exploratory Drilling in the Everglades.”

Why is it important to integrate mathematics and engineering courses with culture and real-life events that impact students? PEEC leaders’ experiences with students and research indicate that, generally, students tend to prefer learning information that is personally relevant and interesting to them, and the same applies with NA students. The use of personal and community-based experiences is a key to student success. Within the ND PEEC, results indicated that successful teachers connect content to students’ lives, and they engage in active learning, as recommended by St. Charles & Costantino (2000). Concepts taught through lecture, textbooks, and worksheets are not always easily absorbed by students; however, experiencing concepts through real-world problems often keeps students engaged and interested, and it promotes deep understanding (Alfson, 2015). A benefit of integrating culture into mathematics and engineering curriculum is to bring a sense of identity back to Native students. In addition, project-based learning, as a teaching method, more closely fits how Natives have traditionally learned through collaboration, observation, and learning through doing, rather than only through classroom lectures and books (Alfson, 2015). Integrating culture into project-based learning helps students to connect mathematics and engineering concepts to the real-world, assists in restoring a sense of identity, and, hopefully, engages students further in the study of mathematics and engineering.

South Dakota

An example of the use of an outdoor laboratory as a low-cost solution from the South Dakota PEEC is a study that investigated selected heavy metals in plants, soils, and water on and near Pine Ridge Reservation. The study was based on samples of plants that are of major local interest, due to their implications for cultural identity among the Dakota and Lakota (Kant, 2013; & Kant, et al., 2015b). One of the project's field sites was deliberately positioned within a half mile of Oglala Lakota College's (OLC's) main administrative campus, *Piya Wiconi*, making it easily accessible to teachers and students in the future. The site has most of the plants of interest (such as wild plums and chokecherries) included in the study, and the location is bisected by an intermittent stream. The site was one source of plant specimens for vouchers for the OLC Herbarium, established during PEEC, with its ties to South Dakota State University's (SDSU's) Taylor Herbarium, whose curator verified plant sample identifications. The entire low-cost package was designed to create interest in STEM, to found what is hoped to be an on-going herbarium at OLC as a permanent low-cost resource, and to include NA cultural ties to increase interest in STEM. Evidence of its likely sustainability includes the addition of many vouchers to the OLC Herbarium from the rare green turtle project area on Pine Ridge Reservation, led by OLC faculty.

As another example of a low-cost solution, engineer Jennifer Benning of SDSMT reported (Benning, et al., 2014) that her team built a simple summer greenhouse that incorporated engineering principles, as follows.

> *We advised an SDSMT senior design team based on a request from OLC [Oglala Lakota College] for sustainable food production design. As a result, a multidisciplinary team of engineers worked on the design of a greenhouse. Mainstream SDSMT [South Dakota School of Mines and Technology] students began the work which required that they learn about cultural differences in order to include*

> *stakeholder participation in the design process. They learned about Lakota culture and challenged some of their long-held assumptions . . . .* (Sawyer, et al., 2014, p. 8)

In the process, they filled a community-identified need for a sustainable food supply through a low-cost solution using local resources, both physical and cultural. They also advanced the image of engineering as a caring profession. Such an image, as noted, is reportedly a matter of importance for NAs of prime college age in South Dakota, if they are to take up engineering studies and careers, according to a recent study by Kant, et al. (2015a).

An OLC instructor, Hannan LaGarry, reported (Tinant, et al., 2014) other examples of low-cost learning solutions awash in community values, as follows.

> *When we show students a place where uranium is exposed in an outcrop, they eventually put together in their heads that their grandma lived within a few miles of this rock, and she died of cancer. That is experiential learning. Sometimes they go back to their families, and they talk about it. That changes their outlook and their learning behavior. Now they drink Oglala Sioux Tribe Rural Water (less uranium), not only well water (more uranium), even if the well water tastes better. . . .* (p.10)
>
> *. . . [T]here are many things to study on PRR (Pine Ridge Reservation), and there is so little competition for scientific research topics. So students have tremendous room to operate . . . .* (p.7)
>
> *. . . We had a mismatched pedagogy and curriculum before. Now we can deliver better teaching through hands-on learning in the field and laboratory. Our students are immersed in the wonder of nature. They tell us what it is that matters to them. It works best when instructors use the lightest touch we possibly can . . . .* (p. 11)

Wisconsin

It is important to note that, although there are opportunities for many of the PEECs to benefit from the low cost research opportunities available within their unique on-reservation ecosystem, the Wisconsin PEEC has not had success with this approach to date. The reason is largely due to restrictions and ordinances of the Menominee Tribe that prevent access to the tribe's managed forested lands for purposes such as PEEC project data collection.

However, the College of Menominee Nation has been able to access forest lands adjacent to the reservation as an alternative. Much of their work to date, however, has involved capacity building rather than research.

CONCLUSIONS

By taking advantage of the opportunities presented to PEECs by their unique landscapes and natural settings, many of the PEECs have found successful ways to integrate and to embed relevant investigations into STEM curricula. The focus on the natural landscape surrounding the tribal colleges helps to motivate students in their STEM pursuits by focusing on science and engineering activities with significant cultural implications. When these outdoor laboratories are available to students, it also provides opportunities in STEM that are readily accessible and can be low in cost. In Wisconsin, this approach has not been successful due to restricted access by tribal government to their managed forests within reservation boundaries. That is not to imply that the tribe should change their position on access; rather, non-reservation forest lands exist nearby, and some of those might serve the purpose. Where access exists, however, as in North Dakota and South Dakota, the impacts on NA students in STEM have been of utmost importance within PEEC.

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Carol Davis with a student from Turtle Mountain Community College presenting a poster at the EPSCoR Biennial Research conference in Fargo, ND. (Photo credit: ND PEEC)

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Hawai'i Indigenous Knowledge in Engineering ('IKE) students and coordinators from all PEEC campuses at the March 2014 huaka'i (excursion) to Keawanui loko i'a (fishpond) on Moloka'i island. (Photo credit: Daniel "Bubba" Lipe)

22.
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McCoy's role in PEEC was at the beginning when the pre-engineering program at the community colleges at UH was being conceived in 2008.

He was part a team that met and devised the concept, its organization, and the proposal for funding. After returning from a year’s sabbatical, PEEC had been funded, renamed Indigenous Knowledge in Engineering (‘IKE) at UH, and a new team had taken charge at his home campus (Windward Community College). His continued interaction with PEEC/‘IKE involved organizing courses he taught in earth and ocean sciences towards the pre-engineering program. fmccoy@hawaii.edu

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Parisky's role as STEM developer allows him to provide direct support to faculty working on PEEC initiatives. He became involved with PEEC due to his expertise in science education and his role as STEM coordinator/ developer. For any aspects of PEEC he served in a support role, working with faculty such as Floyd McCoy and Joseph Ciotti to enhance and support their programs. alex.parisky@hawaii.edu

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>Manuela Romero holds a Bachelor's degree in social science from San Diego State University and Master's and Doctoral degrees in Sociology from Stanford University. She joined University of Wisconsin-Madison (UW-M) in 2005. At UW-M, she serves as Associate Dean for Undergraduate Affairs for the College of Engineering. She oversees undergraduate student services, including student services centers, engineering student development, undergraduate learning center, and diversity affairs.

Romero serves as the PI for the Pre-Engineering Education Collaborative (PEEC) collaborating with the College of Menominee Nation, and she is a Co-PI of the Wisconsin Alliance for Minority Participation. mromero@wisc.edu

>Tammy Salmon-Stephens holds a Bachelor's degree in Industrial Engineering and a Master's degree in Engineering. She is the Director of the College of Engineering, Mathematics, and Science Student Success Programs, having served at University of Wisconsin-Platteville (UW-P) for 20 years. She advises the Society of Women Engineers collegiate organization. She is actively involved in $3-4 million of grants to support women in STEM and student success. She is the recipient of the University of Wisconsin System Outstanding Academic Staff Award, UW-P Woman of the Year Award, the UW-P Outstanding Recent Alumnus Award, and the INSIGHT Into Diversity 2016 Inspiring Women in STEM Award.

She has served as Co-PI on the UW-P PEEC program since 2010. salmont@uwplatt.edu

<>James Sanovia holds a B. S. in Geological Engineering from SDSMT, where he is currently in a Master's program. He serves as the GIS, LiDAR and Remote Sensing Laboratory manager and as an instructor at Oglala Lakota College (OLC). He owns Makowapi, a geological and cultural mapping company. Sanovia is enrolled with the Rosebud Sioux Tribe and has served as PEEC faculty at OLC for several years. In 2016, he also became a PEEC Co-PI. jsanovia@olc.edu

<>J. Foster Sawyer holds an M.S. in Geology and a Ph.D. in Geological Engineering from SDSMT. He is an Associate Professor in the Department of Geology and Geological Engineering at the South Dakota School of Mines and Technology (SDSMT). His research focuses on ground water and surface water investigations, geologic mapping, and studies of fine-grained sedimentary geologic formations in the Rocky Mountains and Northern Great Plains. He is a faculty mentor for the Tiospaye in Science and Engineering program and the SD Jump Start program at SDSMT.

He has served as the PI of the SDSMT PEEC since 2010. Foster.Sawyer@sdsmt.edu

<>C. Jason Tinant holds an M.S. in Civil Engineering from South Dakota School of Mines and Technology (SDSMT) and is a Ph.D. student at SDSMT. He is Assistant Professor of Mathematics and Science at Oglala Lakota

College (OLC), Kyle, SD. He has served as Chair of the Mathematics, Science, and Technology Department at OLC. Tinant has worked to improve the quality of water and environmental science on the Pine Ridge Reservation by creating the OLC-OST (Oglala Lakota College-Oglala Sioux Tribe) archives, developing a joint OLC-OST macroinvertebrate sampling and analysis program, and as lead author for the Watershed Management and Protection Plan reports for the OST 106 and 319 programs. Tinant serves on STEM education and Water Resources advisory boards including: *Tiospaye* in Science and Engineering S-STEM programs at SDSMT, and the Great Plains Tribal Water Alliance.

He has served as OLC's PI for OSSPEEC (NSF #1037708), and several other TCUP awards including: TCUP *Yuowanca* (NSF #0903686), and TCUP *Woksape Kici Woitinze* (NSF #1461479). JTinant@olc.edu

>Ann Vallie holds a B.S. in Electrical Engineering from North Dakota State University (NDSU). She is a Pre-Engineering instructor at Turtle Mountain Community College (TMCC). She is also the Director of an Advanced Manufacturing grant provided by the Department of Energy. She serves as an advisor for the rocket team at TMCC. She also served as the advisor for the American Indian Science and Engineering Society Chapter at TMCC from 2011-2014. She has mentored and taught high school and middle school students at STEM Summer Camps, and Sunday Academy STEM initiatives during the school year from 2011 to the present. avallie@tm.edu

Students from North Dakota tribal colleges doing field work in a surveying course at NDSU summer camp. (Photo credit: ND PEEC)

23.
Epilogue

Professor M. R. Hansen of the South Dakota School of Mines and Technology (SDSMT) first suggested the idea of a book about the Pre-Engineering Education Collaborative (PEEC) in summer 2011 at a faculty and staff meeting at the *Piya Wiconi* campus of Oglala Lakota College (OLC) near Kyle, South Dakota. It was the end of summer, and all of the South Dakota PEEC leaders present at the meeting, were energized and enthusiastic about work completed during that first summer's fieldwork session. Hansen rallied the team when he asserted, "You know, there should be a PEEC book! What's happening here is really important." Everyone present roared in agreement.

The PEEC book idea was promptly forgotten. In the years that followed, the topic of a book was not mentioned again because PEEC participants were busily carrying out tasks to meet the needs of the program. It was a time of great excitement and activity. The PIs and the rest of the leadership team continually recruited even more faculty, staff, and both graduate and undergraduate students, and PEEC motored along. While PEEC is a year-round program, summers are particularly busy. The South Dakota PEECs' summer schedules include an intensive list of research and experiential learning projects, including significant fieldwork activity on Pine Ridge Reservation at OLC with headquarters at their *Piya Wiconi* campus. *Piya Wiconi* is an hour and a half east of SDSMT, and six hours west of South Dakota State University (SDSU) by vehicle.

Normally, all of the PEEC partners in four states receive a Request for Proposals (RFPs) from the National Science Foundation every three years during the lifespan of the program. When the RFP arrived in 2015, each PEEC was eligible to apply for funding for activities that were not for implementation of PEEC but, rather, activities that constituted a logical extension of the PEEC model. The editors of this book considered Professor Hansen's 2011 comment about the need for a South Dakota PEEC book. But to take his idea a step farther, they remembered that every PEEC RFP from NSF encourages the applicant to show how they will disseminate their results to help make projects scalable, that is, to provide impact on a broad scale. Thus, the editors began thinking about more than just a South Dakota PEEC book. South Dakota PEEC leaders had met a few PEEC leaders from other states and from the NSF at two All-PEEC conferences in Minneapolis over the years. Why not help build a broad-based book in which all PEEC participants from Hawai‘i, North Dakota, South Dakota, and Wisconsin would be invited to share their experiences, outcomes, best practices, lessons learned, and recommendations?

It seemed like an overly-ambitious undertaking, but the editors decided to try it anyway. They began to plan logistics. It all began with monthly conference calls to everyone they could find who was, or is, part of the overall PEEC leadership team. The editors enlisted the help of an All-PEEC book Advisory Council, as suggested by Carty Monette, to guide the project. Through a consensus of opinions on the conference calls, lead authors and their co-authors were recruited and provided with a suggested list of chapter topics and a template for style. Champions from PEEC stepped forward to provide the text and photos. Many are first-time authors, some of whom were mentored by experienced co-authors. Small stipends were offered to those participants from Native-Hawaiian-serving colleges and tribal colleges as an incentive to be part of the project.

The production of the All-PEEC book has been thrilling, exhilarating, and sometimes exhausting. The editors knew that the road would not be an easy one, simply because of the logistics of bringing together so many people from so many colleges and universities in four states. It has been an incredible journey, and participants have learned so much from other PEECs and how they operate. It has been heartwarming to hear from PEEC leaders in other states, that they find value and new ideas in learning how others have implemented PEEC. Through the production of the book, many PEEC leaders have gained close colleagues who are easily accessible by e-mail or telephone by using the project’s PEEC Directory, facts assembled on an Excel sheet. The best part of the All-PEEC book is that it has brought a large percentage of all of PEEC advocates together in a way that attending a conference never could.

Thank you to everyone who stepped forward to make the book a reality. For those who labored above and beyond the call of duty, you know who you are. Thanks to Tammie Mohr, Graphic Designer of Allegra Brookings for book layout.

Some might ask, “What is the single most surprising thing that you learned about PEEC during the production of the book?” The answer is, the importance of the year-long sabbatical by Bob Pieri, the North Dakota State University PEEC PI. What he accomplished in that year to build capacity among tribes in North Dakota deserves its own book.

Suzette Burckhard and Joanita Kant, Editors
December 2016

Hawai'i students at the Marine Education Training Center studying vessels, including a double-hulled voyaging canoe. (Photo credit: Hannah Aldridge)

Hawai'i students constructing their own 'iako (outrigger boom) to stabilize their vessel. (Photo credit: Hannah Aldridge)

Hawai‘i students visiting Paepae o He‘eia, a fishpond in Kāne‘ohe on O‘ahu. (Photo credit: Hannah Aldridge)

Hawai‘i students constructing their own ‘iako (outrigger boom) to stabilize their vessel. (Photo credit: Hannah Aldridge)

Hawai'i students at the Marine Education Training Center studying vessels. (Photo credit: Hannah Aldridge)

Turtle Mountain Community College students installing an infiltrometer. (Photo credit: ND PEEC)

Camp Day 3 -- 2014 NDSU PEEC: PTiPS Summer Camp STUDENT General Schedule

First Week: 4 Aug. – 10 Aug.: Academics | Math Boot Camp | Communication Skills | Engr. Prof. Development | Scenario

Dynamics & Math & Comm Dolve 204 / Surveying ECE 213/ Computer Cluster Elhy 119 / Break timing +/- 30 Min

Check in Sunday LLC-W 8/3/14 6:00-7:30 pm.

Meeting at 7:30 pm

Date / Time	MONDAY 4 August	TUESDAY 5 August	WEDNESDAY 6 August	THURSDAY 7 August	FRIDAY 8 August	SATURDAY 9 August	SUNDAY 10 August
7:30	Breakfast **RDC**	Breakfast **RDC**	Breakfast **RDC**	Breakfast **RDC**	Breakfast **RDC**	Breakfast **RDC**	**Free Time**
8:00	Opening	1st Year / 2nd Year	1st Year / 2nd Year	1st Year / 2nd Year	1st Year / 2nd Year	1stYear / 2nd Year	
	Ceremony	Surveying / Thermo	Surveying / Thermo	Surveying / Thermo	Surveying / Thermo	Surveying / Thermo	
9:00	*Break (20)*						
	EVERYONE	*Break (20)*	*Break (20)*	*Break (20)*	*Break (20)*	*Break (20)*	
10:00	Math Review						
							Brunch
11:00							
12:	Lunch (45) **RDC**	Lunch (45) **RDC**	Lunch (45) **RDC**	Lunch (45) **RDC**	Lunch (45) **RDC**	Lunch (45) **RDC**	Lunch (45)
	1st Year / 2nd Year						
1:00	Surveying / Thermo						
2:00							
						Travel	
3:00	*Break (20)*	*Break (20)*	*Break (20)*	*Break (20)*	Student Financial Services	*Break (20)*	
			TRIO- Ray Smith		Brigit Sprenger		
4:00							
5:00							
	Dinner (60) **RDC**	Dinner (60)	Dinner (60) **RDC**	Dinner (60) **RDC**	Dinner (60) **RDC**	Dinner (60) **RDC**	Dinner (60) **RDC**
6:00							
			Scenario: Individual Research papers due: @ ~~9:30~~ 10 pm.	Multicultural Programs-			
7:00				Ruth Grimmett-Tejedor	**Scenario: Individual draft Exec. summary due: ~~8~~ 10 pm 8/8**		
8:00							
9:00						Free Time Movie???	
10:							

Check out of dorms @ 4:00 pm

Check into Days Inn

Camp Day 3 -- 2014 NDSU PEEC: PTiPS Summer Camp STUDENT General Schedule

2nd Week: 11 Aug - 17 Aug: Academics | Math Boot Camp | Communication Skills | Engr. Prof. Development | Scenario

Dynamics & Math & Comm Dolve 204 / Surveying ECE 213/ Computer Cluster Elhy 119 / Break timing +/- 30 Min

Date / Time	MONDAY 11 August	TUESDAY 12 August	WEDNESDAY 13 August	THURSDAY 14 August	FRIDAY 15 August	SATURDAY 16 August	SUNDAY 17 August
7:30	Breakfast **RDC**	Breakfast **RDC**	Breakfast **RDC**	Breakfast **RDC**	Breakfast **RDC**	**NOTE: Meet in Lobby for shuttle.**	
8:00	1st Year / 2nd Year	1st Year / 2nd Year	1st Year / 2nd Year	1st Year / 2nd Year	1st Year / 2nd Year		
	Surveying / Thermo	Tour Fargo Microsoft Campus @ 9:00 am	Surveying / Thermo	Surveying / Thermo	Surveying / Thermo		
9:00				*Surveying Houston Engineering@9:00am*			
	Break (20)		Break (20)	Break (20)	??Break (20)		
10:00							
11:00							
				Final Exec Smmry			
NOON	Lunch (45) **RDC**	Lunch (45) **RDC**	Lunch (45) **RDC**	Lunch (45) **RDC**			½ Hr Discussion
					Lunch (120) **RDC**		with NDSU
1:00							committee for
					Travel Home		1st Yr engineering
2:00	Admissions		1st Group		**BREAK DOWN CAMP**		Experience
	Adam Lundquist		Equine Leadership Sessions				Rm 201, Dean Bld
3:00	Break (20)	Break (20)	Break (20)	Residence Life			
				Jason Medders			
4:00							
5:00							
	Dinner (60) **RDC**	Dinner (60) **RDC**	Dinner (60) TBD	*Picnic at Oak Grove Park-Shelter #2*			
6:00	**Scenario: Recorded discussion of final Executive Summary**		2nd Group				
		TBD					
7:00							
8:00			**Final Proposals Due 8/14 @ 8:00 am**				
						FYI: NDSU Classes start at 4 pm on 25 Aug	
9:00	*Feedback following*						
	Recorded Discussion						
10:							

Students from North Dakota tribal colleges doing the field work in a surveying course at NDSU summer camp. (Photo credit: ND PEEC)

Nueta Hidatsa Sahnish College student Geneva Good Bear on a roadway project. (Photo credit: ND PEEC)

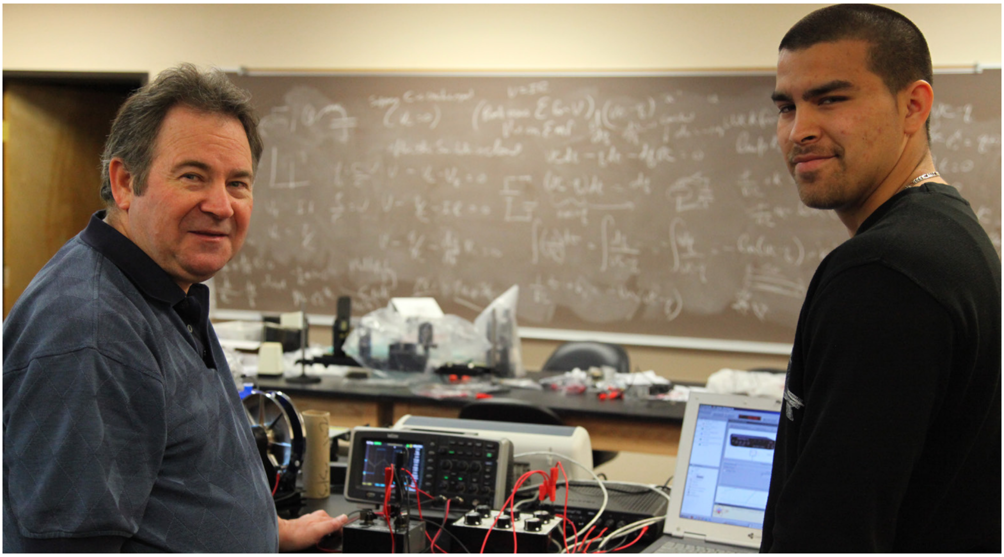
Foster Sawyer of South Dakota School of Mines and Technology and James Sanovia of Oglala Lakota College explain field geology to SD PEEC students on Pine Ridge Reservation in summer 2013. (Photo credit: Joanita Kant)

SDSU PEEC interns, preparing Pine Ridge Reservation water samples for microwave digestion prior to ICP-OES (Inductively Coupled Plasma-Optical Emission Spectroscopy) in the Water and Environmental Engineering Research Center (WEERC) laboratory at SDSU, summer 2012. (Photo credit: Joanita Kant)

Students in the South Dakota PEEC monitor fish populations in streams on the Pine Ridge Reservation. (Photo credit: J.F. Sawyer)

Genevieve Sandoval Bull Head and Zach Buechler, South Dakota PEEC students, assembling the climate control system for a sustainable greenhouse on the Pine Ridge Reservation. (Photo credit: J.F. Sawyer)

Willis Zephier, Oglala Lakota College PEEC student; and South Dakota School of Mines & Technology faculty member, Dan Dolan, surveying the building site for a sustainable greenhouse on the Pine Ridge Reservation in South Dakota. (Photo credit, J.F. Sawyer)



The PEEC funding from NSF helped equip the College of Menominee Nation's (CMN's) physics classroom for faculty and students like faculty member Cody Martin, left, and CMN's first engineering program graduate, Charles James, right. (Photo credit: CMN by DKakkak)

The NSF's PEEC Initiative provided funding that enabled College of Menominee Nation to build and equip a stand-alone Physics/Engineering Lab on the College's main campus on the Menominee Reservation in Northeastern Wisconsin. (Photo credit: CMN by DKakkak)

Ariel Sanapaw, an enrolled Menominee and a descendant of the Stockbridge-Munsee tribe, was College of Menominee Nation's first Pre-Environmental Engineering Technology graduate (May, 2016). She is now pursuing baccalaureate studies in engineering at the University of Wisconsin-Green Bay. (Photo credit: CMN by DKakkak)

Faculty member Lisa Bosman chairs College of Menominee Nation's (CMN's) Engineering Department and is the founder of CMN's Solar Energy Research Institute. (Photo credit: CMN by DKakkak)

The College of Menominee Nation's active-learning Introduction to a Statistics course was developed through PEEC funding. Faculty member Lisa Bosman, left, watches student Whitney Pluger use a LEGO windmill and fan for simulation to capture data that will then be analyzed using Excel software. (Photo credit: CMN by DKakkak)