

**A University-Tribal Colleges-High Schools  
Partnership to Increase Native American College Graduates in  
Mathematics, Science and Engineering**

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#### Abstract

Over the last two decades, the relatively small percentage of Native American (NA) students earning science and engineering degrees has not increased in spite of the fact that one third of NA first-year students enrolled in four-year colleges and universities had the intention of majoring in science or engineering, according to a 1998 survey. Recent declines in engineering enrollment among the underrepresented minorities are disproportionately higher than the decline among non-minority students. Several factors including lack of adequate pre-college preparation, academic intervention programs, and financial assistance could contribute to the current situation. Regardless, programs to increase NA participation in and successful completion of engineering degrees are needed. Such programs need to render the pathways of NA students from middle school through tribal colleges to universities smooth. Activities directed toward pre-college students in such programs need to involve tribal college, university, and school faculty in the development and implementation of those activities. This paper describes the experience of the authors in a multi-year, multi-site project funded by the Office of Naval Research providing enhancement activities for reservation middle and high school students and activities to facilitate smooth transfer of tribal college students to four-year colleges or universities. The student activities in the project were planned, designed and implemented jointly by tribal college, university, and high school teachers. The program has been a success not only in terms of the increased student enrollment in the activities but also by systemically impacting tribal college, university, and high school faculty. A core group continues to work together for the continuation and improvement of the activities. The paper focuses on the partnership development and the systemic impact of the project. For brevity details of the project activities are not included, but will be made available for discussion at the conference.

#### I. Introduction

There is concern among the Native American (NA) educators nationally about the lack of NA participation in science, mathematics and engineering (SME) careers. Over the last two decades, the relatively small percentage of NA students earning science and engineering degrees has not increased in spite of the fact that one third of NA first-year students enrolled in four-year colleges and universities had the intention of majoring in science and engineering, according to a

1998 survey<sup>1</sup>. Recent declines in engineering enrollment among the underrepresented minorities are disproportionately higher than the decline among non-minority students<sup>2</sup>. Several factors including lack of adequate pre-college preparation, academic intervention programs, and financial assistance could contribute to the current situation<sup>3</sup>. Resource limitations in the pre-college education of underrepresented minority students suggest the need for a variety of strategies including enrichment and intervention programs<sup>4,5,6,7</sup>. Regardless, programs to increase NA participation and successful completion of engineering degrees are needed. This would involve instituting programs not only to motivate the NA middle and high school students to pursue college education in engineering but also to guide and nurture them through their academic pathways till graduation. As a first step to address this concern there is a need for programs designed to motivate and cultivate interest among NA high school (HS) students in SME disciplines. According to Charleston<sup>8</sup>, there are three levels of Native education: Pseudo, Quasi, and True. 'Pseudo' is a non-Native solution in which Native students are taught the standard American curriculum assumed to be needed to assimilate into American society. 'Quasi' is teaching Native cultural topics with a heavy emphasis on the non-native mainstream culture. 'True' Native education needs to emphasize both high quality academics and the use of Native culture to teach Native students. In this effort the need to include the tribally-controlled community college (TCCC) faculty and the school teachers in the activities can not be overemphasized<sup>9,10</sup>. In order to sustain the impact of these special activities on HS students, their mathematics and science teachers need to be involved in the development and delivery of these activities. This engagement also applies to the TCCC faculty. Approximately 52 percent of NA undergraduates were enrolled in 2-year colleges in 1996. Of all NA students who earned bachelor's degrees in 1995 and 1996, 20 percent had earned associate degrees from 2-year colleges<sup>11</sup>. Since a significant percent of the NA students transfer from 2-year to 4-year institutions, eliminating barriers for potential transfers could be beneficial for students seeking engineering education<sup>3</sup>.

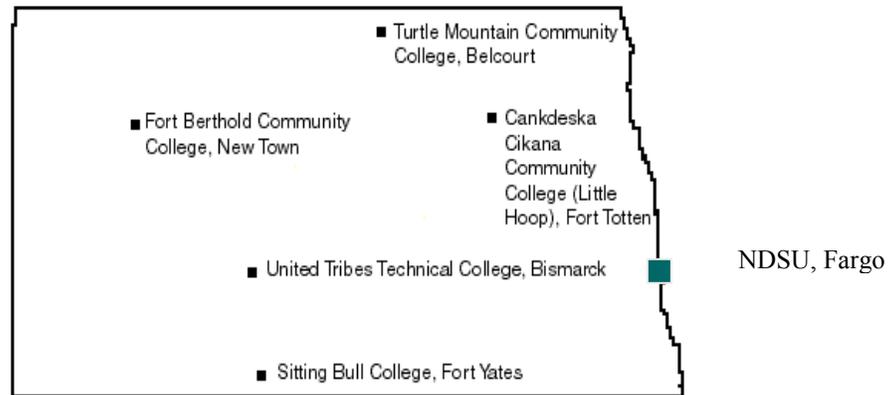
North Dakota is a sparsely populated state with few urban centers and a vast rural area. There is a sizable NA population concentrated in the Reservations of the state. Each Reservation is served by a TCCC to meet the higher educational needs of the tribe members. Typically Reservation high schools feed the TCCCs. There are two major universities in the State that draw students straight from the Reservation schools and from the TCCCs. The North Dakota State University (NDSU) College of Engineering and Architecture and the five TCCCs in North Dakota collaboratively obtained a 5-year multi-site grant from the Office of Naval Research, United States Navy, to increase NA participation in SME disciplines<sup>12</sup>. The project began in June 1999 and was scheduled to end in May 31, 2004. Turtle Mountain Community College (TMCC), Belcourt, ND, was the lead TCCC. Other participating TCCCs are Cankdeska Cikana Community College (CCCC), Fort Totten, ND; Sitting Bull College (SBC), Fort Yates, ND; Fort Berthold Community College (FBCC), Newtown, ND; and United Tribes Technical College (UTTC), in Bismarck, ND (Figure 1).

## II. TCCCs-NDSU Prior Collaboration

As a land grant institution, NDSU has always been keenly aware of the TCCCs positive impact on their communities despite their limited resources. A call for proposals sponsored by the Department of Education's Fund for the Improvement of Post Secondary Education (FIPSE) served as a catalyst for dialogue between TMCC and NDSU administrators and engineering

faculty. This dialogue considered the needs of students who transfer to NDSU engineering program and the potential support that would increase their retention and completion rates. A site visit to TMCC provided an opportunity for the faculty and staff of the two institutions to meet face-to-face and discuss the educational needs and challenges of the TMCC students who were transferring to NDSU. This discussion formed the basis for the collaboration producing the Office of Naval Research (ONR) proposal.

Figure 1. Participant Tribally Controlled Colleges



### III. ONR Project Foundations

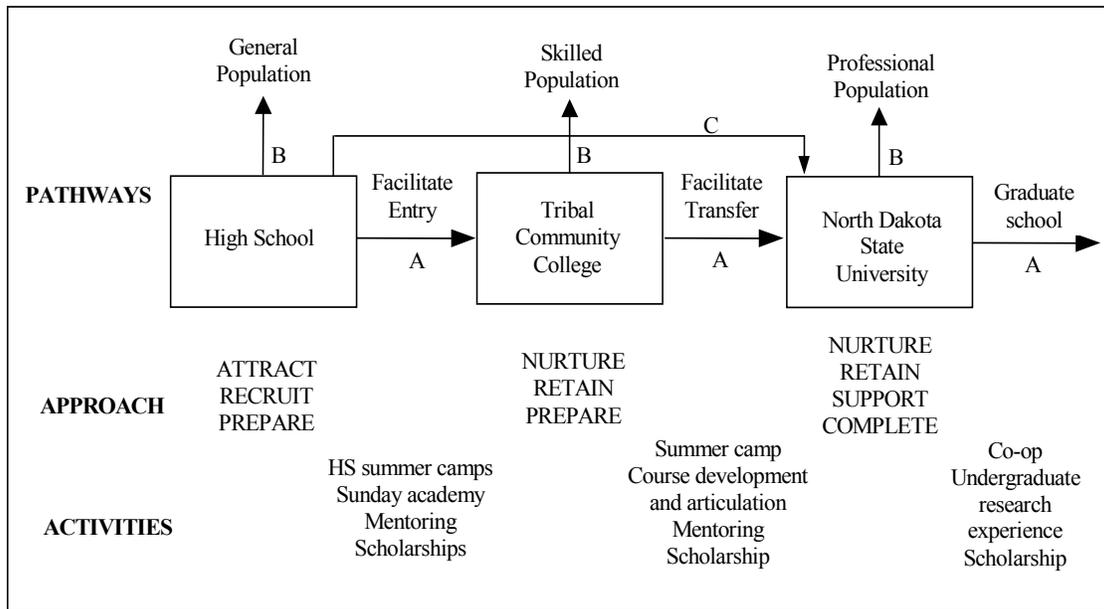
The initial steps of the ONR proposal process began with a chance meeting of the TCCC administrators with an NDSU engineering faculty at the 'Engineering Articulation Summit' conference held in South Dakota School of Mines, Rapid City, South Dakota in May 1998. The purpose of the conference was to discuss articulation of courses taught at tribally controlled colleges to universities. The delegates in small groups discussed and generated ideas for developing collaborative projects to attract NA students to SME degree programs. They also agreed to seek funding to get a collaborative project started. The opportunity presented itself in July of 1998 when TMCC received a Request for Proposal (RFP) from the Department of the Navy, Office of Naval Research. This RFP invited proposals from minority institutions for programs designed to help minority students succeed in mathematics, science and engineering careers. The other TCCCs agreed to participate and asked the NDSU Engineering faculty to collaborate<sup>13</sup>.

### IV. ONR Project Mechanics

The project was a collaborative effort between North Dakota's five tribally controlled colleges and North Dakota State University College of Engineering and Architecture. It was a SME initiative designed to nurture North Dakota's NA youth into SME careers by creating a pathway for success<sup>14</sup> (Figure 2). Reservation's high schools do not offer complete pre-college math and science experiences due to remoteness, inadequate facilities, limited staff, and student indifference. It is essential to offer additional math and science exposure to these students to attract and prepare them for SME careers. Activities directed toward pre-college students in such programs need to involve all available resources to include TCCC, university, and HS faculties through the development as well as the delivery of those activities. With this in mind, the student

activities in the project were planned, designed and delivered jointly by the three faculties. The activities were designed to subtly stimulate the interest of NA youth in SME careers and to assist HS faculty to bring about a systemic reform of their curriculum. Project management and activity flow in this highly collaborative project are shown in Figures 3 and 4. Though direct interaction between NDSU and Reservation HS faculties was not envisaged in the original proposal (Fig. 4), it became increasingly clear that such interaction did improve the delivery of the activities considerably.

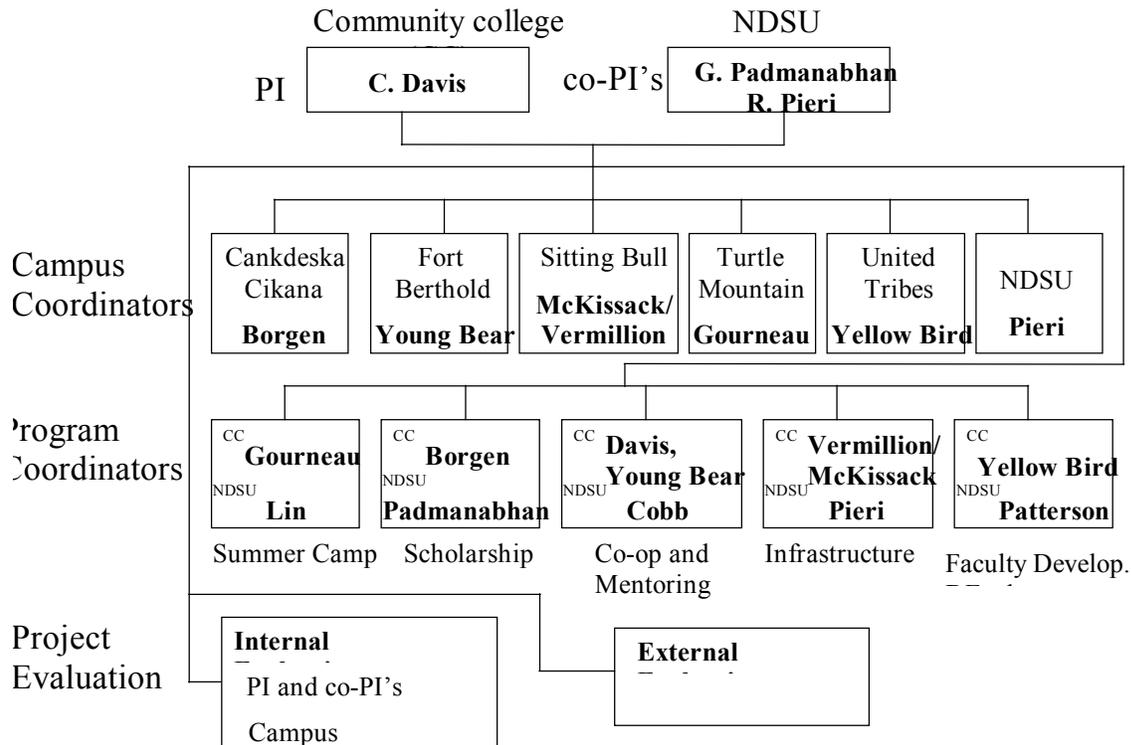
Figure 2. Native American Student Pathways



The grant activities included a series of seven Sunday Academy sessions per academic year, an annual summer camp at NDSU for TCCC students, annual summer camps at each TCCC site for high school students, and scholarships for students. Scholarships ranging from \$1000 to \$5000 at various stages --high school to TCCC and TCCC to NDSU-- were also an element of this project. The respective TCCC campus coordinators administered the TCCC scholarships. The NDSU campus coordinator administered the NDSU scholarships.

The high school component of the project was designed to attract, recruit, and prepare students for entry into tribally controlled colleges by involving them in summer programs and Sunday academies throughout the academic year. Annual summer camps were held at each of the TCCC sites for Reservation school students. Both HS juniors and seniors were included for participation in these camps. While the university faculty members were on the reservations participating in the summer programs, they were introduced to the NA culture allowing them to become sensitive to the students' backgrounds. This HS summer camp component also addressed curriculum improvement at the high school level to complement the career goals of students seeking careers in SME. Upon graduation from high school, the students are expected to either enter the tribal college to seek an Associate of Science degree or as shown in Figure 2 proceed directly to NDSU or other four-year institutions.

Figure 3. Project Management

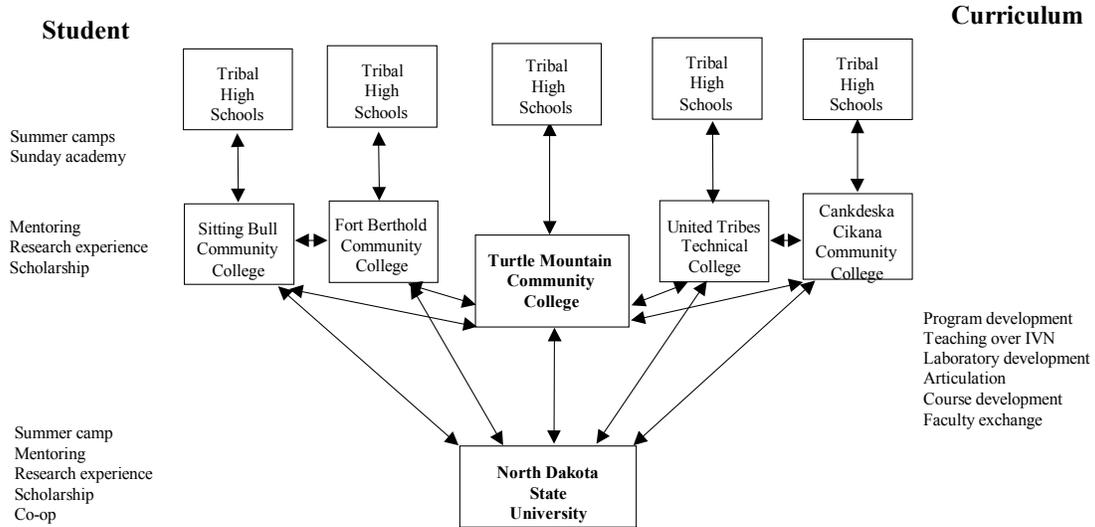


The students enrolled in the TCCCs would find it easier to transfer to the university for SME programs, if the TCCC courses transfer and if the cultural and other adjustments were to be made smoother. The summer camp for the TCCC students was designed for achieving just that. When the students transfer to NDSU, special support systems, including scholarships, are expected to be in place as well as the regular NDSU opportunities for students to participate in cooperative work experience positions with SME professionals in the private sector. The NDSU engineering faculty participating in this project will act as mentors to the NA students, which should enhance their probability for success.

Internal assessments were used in this project to test the effectiveness of all components. These were completed after each activity within all project components. A formative and summative evaluation approach was used. The formative review focused on expectations and implementation. The summative review paid special attention to the actual results as opposed to anticipated results for each objective.

A review of all ONR student participants from the initial period continues. Retention in the ONR activities as well as the academic course work of the ONR students are being reviewed. From this a determination of ONR activities toward the desired outcomes could be accomplished. Initial data indicates that the retention in ONR activities increased. It remains to be determined if there has been an impact on the HS and TCCC courses enrolment of the ONR students and what the completion rate is. Comparisons to non-targeted student populations will be made.

Figure 4. Activity Flow



### V. ONR Project Impact

The five tribal colleges were phased into the project starting with TMCC, then SBC, CCCC, FBCC, and finally UTTC by the last year. The project activities were supported also by other grants such as the Rural Systemic Initiative (RSI), the Experimental Program to Stimulate Competitive Research (EPSCoR), the Biomedical Research Infrastructure Network (BRIN), NDSU, and the Packard Foundation grants. Resources from and collaboration with other NDSU and TCCC programs were constantly sought to continue and enrich the pathway activities. Numbers of students and faculty engaged in the ONR project activities are shown in the following tables:

Student Participation in Sunday Academy Activity at Different Sites

<i>Program Year</i>	<i>TMCC</i>	<i>SBCC</i>	<i>LHCC</i>	<i>FBCC</i>	<i>UTTC</i>
<i>1999-2000</i>	21	n/a	n/a	n/a	n/a
<i>2000-2001</i>	30	28	n/a	n/a	n/a
<i>2001-2002</i>	23	22	15	n/a	n/a
<i>2002-2003</i>	55	18	20	15	5
<i>2003-2004</i>	60	18	15	18	9

Student Participation in TCCC Summer Camps at Different Sites

<i>Program Year</i>	<i>TMCC</i>	<i>SBC</i>	<i>LHCC</i>	<i>FBCC</i>	<i>UTTC</i>
2000	31	n/a	n/a	n/a	n/a
2001	21	21	n/a	n/a	n/a
2002	26	18	18	n/a	n/a
2003	30	22	20	15	n/a

Student Participation in NDSU Summer Camp

<i>Program Year</i>	<i>TMCC</i>	<i>SBC</i>	<i>LHCC</i>	<i>FBCC</i>	<i>UTTC</i>
2000	4	n/a	n/a	n/a	n/a
2001	3	2	2	1	n/a
2002	4	4	2	1	n/a
2003	11	3	2	1	n/a

Faculty/Teacher Participation in Sunday Academy/Summer Camps

<i>Program Year</i>	<i>TMCC</i>	<i>SBC</i>	<i>LHCC</i>	<i>FBCC</i>	<i>UTTC</i>	<i>NDSU</i>
1999-2000	2	n/a	n/a	n/a	n/a	6
2000-2001	4	3	3	n/a	n/a	7
2001-2002	3	3	4	1	1	7
2002-2003	4	3	3	1	1	7
2003-2004	4	3	3	2	1	7

Scholarship Awards

TCCC= 20    NDSU = 14

Curriculum development, cultural integration and lesson delivery, which focus on motivation and retention are more likely realized when the faculty component is also strengthened. Opportunities for collaborative work were created in this project to strengthen the interactive relationship among the university, TCCC and HS faculty. Each year the HS, TCCC, and NDSU faculties work together to develop the Sunday Academy and Summer Camp lessons. The level of understanding and the quality of the lessons improved continually. In-service programs on content and delivery methods were offered to the faculty at the NDSU Summer Camps. Each summer, a three-day workshop was organized at NDSU in which the instructors from all levels worked together to select topics, develop lesson plans and test hands-on activities for the next year's Sunday Academy sessions. The team also developed a proposal to acquire some

instructional equipment and software for the project and to offer specific training for using the equipment. The North Dakota EPSCoR funded the proposal that provided each TCCC site with Global Positioning System (GPS) equipment, Calculator-Based-Laboratories (CBL) instruments and ArcView GIS Software to facilitate the downloading and mapping the data gathered from GPS. Receiving this grant directly enhanced the learning environment of each site. Twelve TCCC and tribal HS faculty participated in workshops to learn theory and hands-on application of GPS, CBL, and the ArcView. Collaborative efforts like these provide professional development opportunities not otherwise possible to the TCCC and HS faculties.

During the course of this project, TMCC and SBC have hired three HS teachers who participated in this project as mathematics instructors in their colleges. This has enhanced the TCCC mathematics and science instruction capabilities. These teachers have remained active in this project and have also helped identify new high school teachers to participate in this project. Retention rate of the original instructors from each site remains high. This consistent faculty core has been directly responsible to the high retention of the students and the high quality of the project activities.

The recognition of the critical role of mathematics skills in the successful transition of the high school students to the TCCC and the TCCC students to the university in the SME career field has triggered an increased emphasis on mathematics skill sets. Each Sunday Academy and Summer Camp lesson had a strong emphasis on mathematics. The emphasis on mathematics skills was carried over to the College Camp. A redesign of the first Summer Camp resulted in a Math Excel short course for the students in the 2001 Summer Camp. Because the students identified this course as one of the most valuable experiences they had at camp, two NDSU math instructors were employed to provide more extensive math experience for the students during the 2002 Summer Camp. The course is being explored at the TCCCs. TMCC developed and tested new approaches including pre and post testing for the math courses. Other TCCCs are also putting in more effort in assessment of math skills of their students. Some results were presented in state conferences on HS SME curriculum improvement. Though the ONR project has seemingly a significant impact it is hard to entirely attribute the impact to the ONR project.

When the NDSU faculty traveled to the TCCCs for the Sunday Academy and Summer Camps, they experienced the NA culture at a variety of levels from the contact with the tribal elders to the interaction with student parents. The cultural activities designed as an integral part of activities helped the NDSU faculty understand the lifestyle of the NA students. Additional activities such as tribal ceremonies, social functions, history lessons, visits to historical sites, and discussions with tribal historians, elders, and officials who carry out the tribal constitutions were also arranged. In addition the camp activities offered opportunities for conversations with the elders and the parents of the students. From these activities NDSU faculty were given an opportunity to learn about the infrastructure on the reservations. The cultural awareness activities of each academic lesson provided the “mentors” with additional opportunities to expand their awareness and sensitivity to students’ culture and needs. This component worked very well.

Responses to the following questions from the TMCC Project Director capture the essence of the ONR Project impacts:

1. What has the approach of this project meant to your campus?

“I believe that the ONR project is a basic, essential building block, which the college can use as a very successful science, math, and engineering program. We will and are using the basis of this program to expand in many other forms of programs and projects which will enhance the math, science areas of TMCC and give the college instant credibility when it comes to quality math and science education.”

2. What impact has the ONR project had on your students at the TCCC and the high school?

“Our TCCC students have made use of the scholarship opportunities available from the ONR grant. The ONR project has also made available opportunities to advance to NDSU with financial support and human support from summer camps at NDSU, without these opportunities, many students would not have taken the chance to advance their education.”

“Our high school students have been made aware that there are educational opportunities for them to take advantage of. The growth of the Sunday academy program serves as unquestionable sign that the ONR project has had an impact. We started the Sunday Academies with 15-20 students per session and ended up with 50-55 students per session.”

3. What impact has this project had on the high school faculty you work with?

“What I can see is that the ONR project has allowed our high school faculty to spread their wings and do some of the things that may not be possible in a school classroom setting. I believe that this program has allowed them to show what they can do, and with very impressive results.”

4. Has the project had an impact on generating other proposals?

“Yes, the ONR activities have been used to support other grant projects such as the NASA/PACE grant, and the ONR activities have been reproduced in other forms to support activities on other levels rather than just the high school.”

5. Other key impacts?

“Just to restate the comments in #1, I believe the ONR project is a definite feather in the cap of TMCC, and it will be used to show the quality of program we can offer, which makes us a definite force in the education field.”

This project has impacted the North Dakota NA Reservations in the following ways:

- The TCCCs continue to develop infrastructure required to address SME at the tribal college level.
- The reservation high schools have become aware of the academic needs of NA students who desire to pursue SME careers and will be able to put programs in place to nurture those students.
- The participating university faculty members have become aware of the diverse needs of the NA students by participating in the cultural awareness activities.
- The TCCC and NDSU faculty have developed a working relationship to continue nurturing NA students.

Some possible future impacts include: Some NA graduates may return to their communities as role models and will be able to address the MSE needs of the Reservations while some others may continue their careers off Reservation and make contributions to the broader society.

#### VI. ONR Project Conclusion

The 5th and final year of the ONR project activities has just concluded. During the project collaborative activities were implemented with five NDTCCs. As a result of this effort, a steady increase in the number of students and instructors participating in the project activities occurred during the project period.

Sunday academies and summer camps reported here are activities that strengthen the pathways to SME careers for NA students of North Dakota. Apart from the direct benefits to students, these activities have created a collaborative and co-operative climate for the NDSU, TCCC and Reservation HS faculty to work together beyond the project boundaries.

At the conclusion of the ONR project, the NDTCC appear confident that they have mechanisms in place on their campus and leadership in their communities to develop and continue similar programs. Also NDSU has faculty who are sensitive to the needs of NA students.

#### VII. ONR Project Follow-On

Efforts continue to guarantee that the solid collaborative foundation developed under the ONR project will expand and become stronger. Obtaining EPSCoR grants to supplement the instructional equipment needs of the project is such a step. The equipment from the EPSCoR grant has been used in numerous lessons already. The students are excited by the new technology and HS teachers are using similar pieces of equipment in their classrooms as appropriate.

Another in-state-project called Biomedical Research Infrastructure Network (BRIN) funded by NIH collaborated with the TCCCs to upgrade their interactive video network (IVN) teleconferencing systems connecting the NDTCCs with other sites within the State or anywhere else. The IVN was used heavily in the Sunday Academy activity of the ONR project to connect all of the tribal sites for sharing lesson discussions and student presentations. The system needs improvement to use it more effectively for laboratory instruction. The work is in progress and additional funding and innovation is expected.

A three-year Pre-College Achievement of Excellence in Mathematics, Science, Engineering, and Technology (PACE/MSET) grant from the National Aeronautic and Space Administration (NASA) was obtained last year by the collaborative team. This project concentrates on the middle school students and teachers for improvement in science, technology, engineering and mathematics (STEM) learning and teaching.

Another Bridges for Engineering Education (BEE) planning grant was obtained this year from the National Science Foundation (NSF). This grant has provided the opportunity to expand the scope of the collaborative team from SME faculty to include Teacher Education faculty at NDSU and TCCCs.

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## Biographical Information

### CAROL DAVIS, PI (TMCC)

Dr. Carol Davis, Vice President, TMCC, is the Principal Investigator of the ONR project. She joined TMCC in 1989 as Academic Dean. She became Vice President in 1994. Her duties include supervision of academic and support programs. She served as a Co-Principal Investigator for a National Science Foundation Rural Systemic Initiative project involving nineteen American Indian tribes in six states.

### G. PADMANABHAN, Co-PI (NDSU)

Dr. G. Padmanabhan is a Professor in the Department of Civil Engineering and Construction at NDSU. He served as the Chair of the department from 1999 through 2003. Dr. Padmanabhan has more than twenty years of teaching experience in engineering. He has attended several engineering education conferences. Of particular interest is one on 'Engineering Articulation Summit', in which articulation of courses taught at tribally controlled colleges to Universities was the theme. Dr. Padmanabhan is a member of ASEE. He is a Fellow of the American Society of Civil Engineers.

### ROBERT PIERI, Co-PI (NDSU)

Dr. Robert Pieri is a Professor of Mechanical Engineering at NDSU. He served as the Chair of the department from 1996 through 2002. Prior to coming to NDSU, ten years of his teaching career were spent as an instructor/professor at the United States Air Force Academy (USAFA). Dr. Pieri has a ten-year involvement with the American Society for Engineering Education and has served as a co-chair for ASEE's new Engineering Educator Division.

### WEI LIN, NDSU

Dr. Wei Lin is an Associate Professor in the Civil Engineering Department at NDSU. He received his Ph.D. in civil/environmental engineering from the State University of New York at Buffalo. Dr. Lin teaches several environmental engineering courses.

### FLOYD PATTERSON, NDSU

Floyd Patterson is an Associate Professor of Electrical Engineering at NDSU. Professor Patterson has several years of experience teaching the introductory and motivational material to Electrical Engineering freshmen. In this course he illustrates physical phenomena in graphical and/or mathematical form using MATLAB.

### SHARON COBB, NDSU

Sharon Cobb has been involved in the development of the NDSU Cooperative Education Program, which realizes over 600 placements annually, with a network of nearly 400 active employers. This campus-wide program served as the employer base for the ONR project. Until recently she directed the Group Decision Center, which was used extensively in the proposal preparation and throughout the project.