AC 2007-1867: EXPERIENCE WITH AND LESSONS LEARNED IN A STEM SUMMER CAMP FOR TRIBAL COLLEGE STUDENTS

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Dr. G. Padmanabhan is a Professor of Civil Engineering in North Dakota State University. He also serves as the Director of North Dakota water Resources Research Institute. He served as the Chair of the Civil Engineering Department from 1999 through 2003. Dr. Padmanabhan has more than twenty five years of teaching experience in engineering. He has attended several engineering education conferences. He has served not only as PI or CoPI but also as instructor of several educational outreach projects to motivate women and Native American middle and high school students to enroll in science, technology, engineering, and mathematics (STEM) programs in colleges. Funding sources for his projects include NSF, Office of Naval Research (ONR), NASA, and Funds for the Improvement of Primary and Secondary Education (FIPSE). The NSF, NASA, and the ONR funding supported a sustained effort to increase Native American participation in STEM areas for the last seven years. Activities of the effort are continuing with funds from the North Dakota EPSCoR program. He has presented and published the experience in American Society of Engineering Education conferences. Dr. Padmanabhan is a member of ASEE. He is a Fellow of the American Society of Civil Engineers.

Robert Pieri, North Dakota State University

Dr. Robert Pieri is a Professor of Mechanical Engineering in North Dakota State University. 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. Dr. Pieri has worked with the tribal college instructors and Reservation high school teachers on several educational outreach projects not only as PI or CoPI and also as instructor and program coordinator. He spent a year of sabbatical at the Turtle Mountain Community College on the Turtle Mountain Reservation helping them with curricular improvements.

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Floyd Patterson is an Associate Professor of Electrical Engineering at North Dakota State University. 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. He has been involved as an instructor in several of the on- and off-campus educational outreach project activities not only with the Native Americans but also with other middle and high school students in the area.

Experiences with and Lessons Learned in a STEM Summer Camp for Tribal College Students

Abstract

Improving science, technology, engineering and mathematics (STEM) education among Native American students and attracting them to engineering programs have been the main focus of a long-term collaboration between North Dakota State University and five tribal colleges in the state. Each year, as part of this multi-pronged effort, a two-week summer camp is organized at the university for tribal college students and tribal high school graduates. The camp is designed and organized recognizing students' cultural and socio-economic background, and specific needs due to their coming from remote rural areas. Objectives of the summer camp include: (1) introducing Native American students to different science and engineering disciplines; (2) exposing the students to research programs and career opportunities; (3) retaining their interest in STEM; (4) provide opportunities to experience campus and urban life; and (5) increasing enrollment in college level science and engineering programs. In the first week of the camp, students visit science and engineering departments, research laboratories and institutions, and industrial facilities to gain general understanding of different scientific fields, and application of science and technology in engineering practice. In the second week, students work in small groups with professors on specific project to learn more about specific disciplines though hands-on and exploratory activities. Exercises in mathematics, journaling, and presentation skills are integrated into daily activities. Students stay on campus during the entire period of two weeks of camp. In addition to academic activities, various social activities, such as sports, games, and visiting local Native American groups, are also organized. A group of university professors work closely as a team with the participating students in organizing activities, developing lesson materials and projects, and learning the challenges facing the students and their needs. In this paper, the camp components and the efforts to improve camp activities are discussed in detail. Outcomes of the camp are evaluated for their impact on the students and professors. Lessons learned from this summer camp provide a better understanding of learning styles and specific needs of Native American students, and will be beneficial for developing similar educational outreach programs.

Introduction

Native Americans are going into higher education in greater numbers and have made progress in participating in math, science and engineering fields nationwide. Number of science and engineering baccalaureate degrees awarded to Native Americans has increased from 1,290 (0.4%) in 1987 to 2,782 (0.7%) in 2000 (Babco, 2003). However, Native Americans only represented slightly over 1% of the total undergraduate enrollment, and they are still more likely to be enrolled in two-year institutions. In 2001, Native Americans represented 1.3% of the total enrollment in two-year institutions and 0.8% in four-year institutions (Babco, 2005). This may be explained by the fact that most Native American Indians attend colleges and universities where their population is concentrated. Although Native American students are just as likely to pursue

degrees in science and engineering fields as other underrepresented ethnic/racial groups, Native Americans did not attain a share of degrees equal to their share of the population age 20 to 24 at any degree level (National Science Board, 2006). Native American increases in degree attainment do not yet match their enrollment proportion. Attainment increases have also failed to keep pace with Native American population growth.

North Dakota is a sparsely populated state, with nearly half of its 640,000 residents residing in rural areas. A combination of large geographical area and small population presents educational challenges in North Dakota that sharply contrast with those of high population states and large metropolitan areas. North Dakota also has a high percentage of Native Americans, 5.2% as compared to 1.0% American Indians and Alaska Native nationwide (U.S. Census Bureau). Most of North Dakota's >35,000 American Indians reside on five reservations, and 43% of this population is under the age of 20 years.

There are five tribal colleges in North Dakota, These tribal colleges are making great strides toward enriching the lives of tribal members through educational opportunities available on each reservation. A primary concern of the tribal colleges is the low number of Native American students who attempt and succeed in career paths that require an advanced level of mathematics, science, and technology skills. These professions are not only critical to the future development of this country but also to the development of reservations where the tribal colleges are located. Increasing the numbers of successful Native American students in mathematics, science and engineering courses at two-year tribal college level and four-year university level remains high on the list of priorities.

Although they represent about 5.2% of the total population of North Dakota, the number of Native American students enrolled in North Dakota State University is only 1.0% (Office of Institutional Research and Analysis, 2005) of total students. The percentage of Native American enrollment in math, science and engineering programs is even lower.

Since 1998, a team of North Dakota State University engineering, math and science professors has been working with the five ND tribal colleges focusing on improving STEM educations on the ND Indian Reservations to create a pathway for Native American Students pursuing career in STEM disciplines (Padmanabhan et al., 2004). The major components of this program include: summer camps for tribal college and for tribal college instructors and high school teachers at the university, summer camps for middle and high school students at tribal college, weekend academy for tribal high school students during academic years (Lin et al., 2006), and research collaboration between the university and tribal colleges. Through the years, the program has received funding from Office of Naval Research (ONR), NSF TCUP and BRIDGE programs, NASA PACE program, and North Dakota EPSCoR. Currently, the program is supported by the North Dakota EPSCoR under the title Nurturing American Tribal Undergraduate Research and Education (NATURE).

In this paper, the design and implementation of and lessons being learned in the summer camp at the university are presented. This two-week summer camp is offered to North Dakota tribal college students and tribal high school graduates who are entering tribal colleges. The camp has been conducted for the past 7 years with the following goals:

(1) Introducing students to different STEM disciplines;
(2) Exposing the students to research programs and career opportunities;
(3) Retaining their interest in STEM;
(4) Improving their capability in mathematics;
(5) Provide opportunities to experience campus and urban life; and
(6) Increasing enrollment in college level science and engineering programs.

Summer Camp Design and Components

Through literature review, survey of tribal high school and college students, and meetings with tribal college administrators and instructors, several factors have been identified as to why Native Americans are not studying science and engineering in greater numbers. Some specific issues in relation to North Dakota tribal students are:

1. Poverty is a major determinant for the quality of education by children, and that quality, in turn, a major determinant of interest in and participating in science and engineering career (Babco, 2003). Although North Dakota has lower unemployment rate than national average, unemployment rates on reservations are typically higher than 50%. Lam (1997) reported that in 1993, 90 percent of all persons in Standing Rock between the ages of 16 and 64 earned less than $7,000. For that year, unemployment on the reservation was at a staggering 86 percent of the "potential labor force."
2. Lack of exposure to modern industries and lack of understanding of STEM career opportunities. Most Native Americans live on the reservations, which on average are more than 100 miles away from major industries and population centers. Most students surveyed in the program had little idea about career opportunities for people with math and science degrees and could not tell the differences among engineering disciplines.
3. Tribal school students are underserved by the educational system in terms of gaining scientific and quantitative literacy (Babco, 2003). Teacher shortages and improper training in new technologies; a lack of facilities, resources and technical supports; and inappropriate curricular designs have contributed to lower achievement of Native American student sin STEM related content areas (Lin et al., 2006)
4. Cultural background and family traditions. Natives Americans have very strong ties with family members and most students from reservations have never left their family for extended period. City and campus life appears so strange to them.

To address the above difficulties faced by Native American students, the camp was designed to include both academic and social activities. Social activities are imbedded through the two weeks of the camp and most of these activities are arranged for the evenings and weekend. Academic activities were designed to expose students to various STEM careers, to introduce students to different STEM disciplines, and to provide opportunities for the students to explore their interests in specific STEM subject or area.

Academic Activities – Week 1. The first week activities are design to expose the students to deferent STEM related academic programs; to make them understand the needs and importance of studying mathematics and basic sciences, and their connection to engineering education, and to introduce them to career opportunities for various STEM disciplines, as depicted in Figure 1.

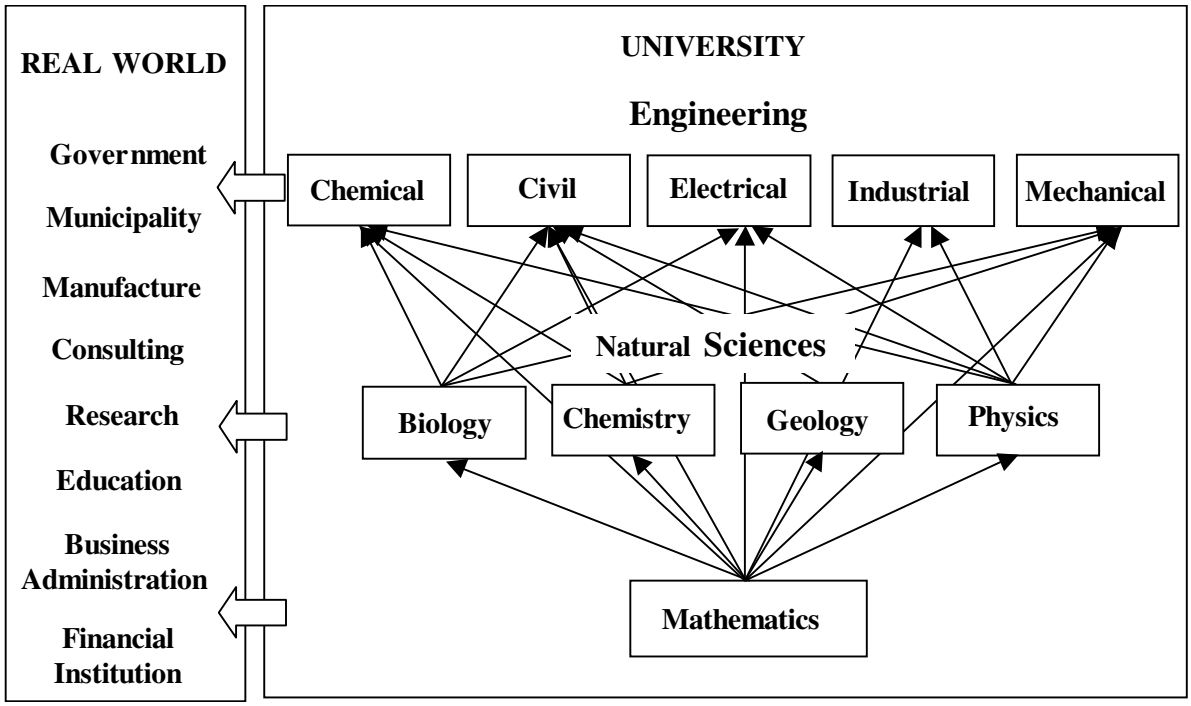

Figure 1. Typical STEM Based Model of Education

The activities of week 1 include visiting science and engineering departments, visiting research centers and laboratories, touring industrial and municipal facilities, and adding presentations by successful Native American engineers and professionals.

Campus visits were supported by a wide range of departments and research institutions, including:

- Engineering: Agricultural, Civil, Electrical, Industrial, and Mechanical.
- Science: Biology, Chemistry, Computer, Geology, Physics, Polymer and Coating
- Agriculture: Plant Sciences, Entomology, Soil Science
- Research: Center for Nano-scale Science and Engineering, International Water Institute, Electron Microscopy Center, and Agricultural Engineering Research Pilot Plant

Various activities have been designed by participating departments and institutions to stimulate students' interests. These activities include:

- Visiting labs, observing experimental and operational demonstrations
- Presentation by undergraduate students on their curricular and extracurricular activities
- Video and knowledge games
- Visit of specimen collections

Academic Activities – Week 2. Students are provided with several choices of hands-on projects for the second week. Based on their Week 1 experience, students form small groups of 2 to 3

persons and each group select a project that they are interested in. During this second week, each group will work with a professor or a researcher, who sponsors the project, in his/her lab carry out experiments, collect data, interpret the results and prepare a presentation. Students present their experience and results during the last day of the camp. The projects and activities are designed and carried out to achieve the objectives of strengthening their understanding of the subjects and STEM area they are interested in; applying the knowledge they learned in high school and tribal colleges; involving them in learning/exploring new knowledge through scientific procedures; and building their confidence in studying STEM at college level.

Daily Mathematics. To stimulate students' interests in mathematics and to provide them with better understanding of application of mathematics in different science and engineering fields, a daily mathematics program is carried out throughout the two-week camp. Each day student activities start with the 1.5-hour math activities. The activities, designed by a mathematics professor, include mathematical games, math problems related to daily life and applications, and mini-projects that require application of math skills.

Social Activities. With the assistance of the Multicultural Student Service of the university, a variety of social activities are included to familiarize students to the camp and city life, to learn the university minority student supporting system, and to introduce them to local and campus Native American groups. On campus, Multicultural Student Service arranges visit of it facility and explain the resources available for student supports. Senior Native American students are recruited to present their campus experience and advise students in camp activities, such as daily math. Students are provided with opportunities to play sports and games using the university facility. During the weekend, students and faculty are going out together visiting museums, watching movies, BBQ in park, and shopping in mall. Students also enjoy visiting local Native American group and watching American Indian movies.

Student and Faculty Participation

Students are recruited from the North Dakota tribal colleges by project coordinator on each campus and other participating instructors. Number of tribal college students participated in the camp ranged from 12 to 17 in recent years. Several factors limited the number of students in this camp. The factors are (1) relative small STEM programs at tribal colleges, (2) competition of students with other summer programs, (3) funding limit at some tribal colleges, and (4) summer jobs for some students. Although the summer camp pays a stipend for participants, the level of payment is much lower than most summer jobs. The program is more successful recruiting those students, who have participated in the weekend academy at high school level (See Padmanaban et al., 2004 for details about the weekend academy.)

A group of engineering faculty has been working on this program for the past 8 years. Continuity and dedication are two important ingredients for the success of this program, which include the summer camp at university for tribal college students and other activities. The group is also successful in involving math and science professors and recruiting young faculty members. Numbers of young professors realize the importance of involving minority students and including minority education in their research programs when seek funding from federal

agencies. Some of these young professors were not benefited from this program in pursuing federal funding, but also became key contributors of the program.

Project Examples

Each year, two months before the summer camp, solicitation of project topics is published on the universities biweekly newsletter. Many different engineering and science projects have been made available to the students to work on. To emphasize the current issues and research focuses in the nation and in the state, environment, renewable energy, and nanotechnology were selected as the topic areas for the summer camp of 2006. Seven topics were proposed by professors and researchers, as shown in Table 1.

Table 1. Topics for Student Group Projects

Topic	Advisors	Project Description
Ethanol Production	Scott Pryor, Agricultural Engineering	Students will participate in all steps involved in production of ethanol from corn grain: grain malting, mash/fermentation, and distillation.
Biodiesel Production	Dennis Wissenborn, Agricultural Engineering	Production of biodiesel from vegetable oil using a base-catalyzed transesterification procedure. The biodiesel will then be washed to remove impurities, dried and analyzed for several key quality indicators.
Solar Energy: Solar Cells	Roger Green, Electrical and Computer Engineering	Exploring the fundamentals of solar cells and conversion of solar energy to electrical energy, and studying the impact of light intensity, and solar panel angles on energy output.
Environmentally Conscious Design and Manufacturing	Reza Maleki, Industrial and Manufacturing Engineering	Discovering the product and process design fundamentals that are more environmentally sound than some of the current practices. The participants also will explore examples of creative product and process design.
Water Quality Monitoring and Testing	Grit May and Derek Crompton, International Water Institute	Work directly with scientists to study water quality issues through field sampling and sample analyses.
Watching Atoms	Uwe Burghaus, Chemistry	Studying and inspecting surfaces of different materials at nanometer scales using a Scanning Tunneling Microscope (STM)
Synthesis of Luminescent Nanoparticles	Julia Zhao, Chemistry Tom Freeman, Electron Microscopy Center	Synthesizing RuBpy-doped luminescent nanoparticles using a reverse microemulsion protocol. Observing the nanoparticles using an electron microscope and learning the applications of the nanoparticles.

Lessons Learned and Challenges

How can we develop academic activities and program contents to suite the needs of Native American students from reservations? What are the unique challenges faced by the reservation youngsters that discourage them from pursuing STEM degrees and career? How can this

program be expanded and provide broader impact on STEM education on reservations? These questions have been discussed by the professors through the years. Many observations have been made, and different approaches have been tried. Following are some of the lessons learned from this program:

1. The students from the reservations are as capable in math and science as other student groups. Many professors commended that these students are "smart" in solving math and scientific problems. However, their initial responses to the challenges are usually passive and they are afraid of making mistakes.
2. Native American students enjoy learning the topics more through hands-on activities, discovery learning, role playing and/or scenarios. However, they need more directions from the advisors. Establishing such an approach is time intensive for instructors and advisors and requires a more creative approach to traditional topics. Nonetheless, it is important to accommodate this need in the instructional activities.
3. Personal relationship between faculty and students played an important role.

These are factors that can be accommodated in designing the instructional activities. For example, the first concern relates to understanding the culture and style of learning of students is addressed by frequent contact opportunities for the faculty through this and other components of the outreach program. The second factor is addressed by including hands-on activities in the lesson plans and providing opportunities for the students to work on exploratory projects and to participate in ongoing research projects. A companion paper in this conference specifically addresses this aspect (Lin et al. 2007). The third factor is addressed through individual or small group mentoring. In fact the faculty team made every effort to do all that and has been successful in retaining the students in the program and sustaining their interest in STEM areas.

Some of the challenges we faced in the camp operation are discussed below. These are issues which need to be worked on for longer period of time on several fronts.

1. Students are prone to homesickness to a unusually high degree
2. Punctuality has a different context for Native Americans and therefore content intensive sessions should be rear loaded.
3. Attitude toward learning – lack of motivation. This could be from their socio-economic background.
4. Less likely to receive support from family and/or the community

These issues are being addressed through other support services in the universities. The outreach program, of which this camp is a component, also addresses some of these issues through other components of the program. For example, students at the camp are provided opportunities to participate in the activities of multicultural student service center, student chapter of American Indian Science and Engineering Society, and other local Native American organizations. In some of the other activities in this outreach program, the parents are invited to provide an opportunity to see their students at work. At least in one other component activity we have seen the encouragement from the parents playing a key role in retaining the students in the activity.

The success of the summer camp depends very much on the successful collaboration among the university professors and tribal college faculty. NDSU faculty and tribal college faculty gain a better understanding of each other's culture. Both need to agree and understand the cultural inhibitions the students may have in pursuing STEM college education. Then it is possible that while the tribal college faculty members work off of their campus to motivate students to attend such camps, the university professors can provide appropriate material and conduct the camp on university campuses. One of the unique features of this camp is both tribal college faculty and the students are on the university campus when the camp takes place. Though the faculty have a parallel track of activities designed for them separately, this camp presents a great opportunity for the tribal college faculty to become familiar with and observe the type of student activities in the camp. Wherever possible the lesson topics if connected with the Native American relevance seemed to get the attention of students better. Stipends are important to attract students because of poverty in Reservations.

Conclusions

A summer camp for the North Dakota Tribal college students was designed and conducted to motivate and attract them to STEM degree programs. Exposure and participation in currently relevant STEM research was included in the camp activities as a special feature along with other curricular and extra-curricular activities. Familiarity with the university atmosphere and faculty strongly influenced the students to feel confident of surmounting the usual challenges they face such as home-sickness, fear of cultural conflicts, and most of all the fear of STEM disciplines for their being perceived as difficult and in conflict with their culture.

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