# Engineering Research Experience for Undergraduates With Topics Important to American Indian Students

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Abstract

An NSF-sponsored research experience for undergraduates (REU) program is described herein. An important objective of this REU program is to encourage retention of American Indian students in the science and engineering disciplines. Originally, the program strategy was to use energy engineering topics of relevance to indigenous peoples. The topic of energy utilization, especially environmental friendly energy utilization, in remote regions appeared be of special interest to Native American students. Over the past two summers, the research topics have been broadened to appeal to the individual interests of the participating students.

## 1. Introduction

For the past three summers the National Science Foundation (NSF) has sponsored an eight-week research experience for undergraduates (REU) program at Arizona State University (ASU). An important objective of the ASU REU program is to encourage retention of American Indian students in the sciences and engineering disciplines. Data indicate that only the 43% of the American Indian students attending higher education institutions are enrolled full time; the graduation rate is 25% and that the first year retention is 45%.[1] When compared to non-Indian students, the rate of studies termination is lower for American Indians. Whereas only 44% of American Indian freshmen either complete their program of studies within one year or returned to school for a second year, the corresponding figure for other groups is 52%.[2]

In view of the high dropout rates and low college enrollment and graduation rates of American Indians compared with all other ethnic groups in the U.S., and the severe under-representation of American Indians in the science and engineering fields, Native professionals in 1977 created the American Indian Science and Engineering Society (AISES) that would serve to identify and remove the barriers to academic success for Native students.[3]

In the past, several projects have been developed to introduce American Indian students to academic activities at the college level as well to increase their recruitment and retention rates.[4,5,6] In some cases, these programs have also the associated goal of encouraging the students to pursue careers in natural and social sciences.[7,8,9]


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2. Research Experience for Undergraduates (REU) Program

The REU project described in this paper has an objective of bringing research work in the area of energy engineering to undergraduate students, using the published NSF REU program as a framework. The NSF REU program has been in place in the Engineering Directorate at the NSF for about 10 years. At other universities REU projects focused on electrical engineering have been organized and proved their efficiency to affirm the motivation of the students.[10,11]

An important feature of this REU program is that it is designed to encourage American Indian students to consider engineering and science as a career. To increase retention the ASU REU students actively participate in energy engineering research projects from a NSF-sponsored Industry/University Cooperative Research Center (IUCRC). The hands-on experience affords participants the opportunity to evaluate career choices in the technical fields. The student interest in pursuing science and engineering careers is increased through exposure to state-of-the-art technical topics.

Energy engineering, largely centered around electrical and mechanical engineering, has a natural appeal to persons from all age and ethnic groups because it concerns our environment, our quality of life, and well being as a society. The REU program strategy is to use topics, not only of research relevance from the center, but also of relevance to indigenous peoples. Native peoples desire to be both self-reliant and self-determined. From an energy perspective such independence would then include the energy source selected (*e.g.*, coal versus solar). The topic of energy utilization, especially environmental friendly methods, in remote regions appears to be of special interest to American Indian students.

Representative research topics include energy utilization in mining industries, energy conservation, assessment of the power supply utilization on the reservation, feasibility of distributed power generation for energy independence, and societal impact of advanced communications. In some cases, elements of energy engineering are taken from and applied to problems unique to rural, reservation regions; for example, the passive use of solar energy for lighting via fiber optic transmission in remote areas. The coupling between energy and American Indian concerns is briefly addressed for a few example projects below:

- *Solar energy in remote sites*. Energy dependence in rural areas, particularly among Native peoples, often creates a financial and technical dependence on distant utilities. The concept of solar energy in rural areas offers energy independence, and there is a potential for economic advantage to both the utility and the tribal consumer.

- *Energy utilization in mining industries*. Several tribal communities are located in mineral rich regions of North America, yet few American Indian engineers and technicians are employed by the mining concerns. The reason can be traced partially to the unavailability of qualified technical persons for these positions.


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- *Feasibility of distributed power generation for energy independence*. The deregulation of the electric industry is causing a focus on distributed power generation. A distributed power generation system consists of small local generators connected to the distribution system directly. The obvious advantage of such a system is the elimination of transmission costs and energy independence.

Although the projects have a large component of electrical engineering, other disciplines of science and engineering are considered.

3. REU Project Example: Passive Solar Lighting

With a focus on energy engineering, the first summer's projects had a central theme related to solar energy use. As noted above the concept of solar energy in remote reservation areas offers energy independence, and there is a potential for economic advantages. In addition, rural electrification options can amount to more than economics: in some cases to realistically receive commercial electrical service, the traditional home site would have to be moved.

In the recent REU project at ASU, one participant from the Navajo Nation indicated that solar energy is not new on the reservation. For example, as one travels around the Navajo reservation in northeast Arizona, several solar homes are seen, but many solar installations are inoperable. The concomitant difficulties of solar residential applications that are not often mentioned are the issues of reliability and maintenance. The basic problem is that the owners are not provided with maintenance and repair information.

One especially interesting aspect of the solar thrust area is the study of passive lighting. Passive lighting refers to the use of renewables like solar energy for residential lighting. The concept studied in the REU is the collection, tracking, and storage of luminous energy. The collection phase consists of the use of mirrors and fiber optic technologies. Costs are an important issue. Tracking generally entails the use of solar sensors to determine the position of a solar collection lens. When the sensors 'see' greater luminous energy in one direction, the collector is moved. Otherwise it remains fixed. Figure 1 shows a schematic of the system.

The storage phase involves the study of chemiluminescence and phosphorescence. These technologies have been recently commercialized through the sale of residential driveway lights that store solar energy. The concept is to use chemiluminescence to store luminous energy during the day and use it at night. The concept gives an especially feasible application in traditional living environments (*e.g.*, a Navajo hogan or traditional roundhouse). This thrust area offers the real possibility of illustrating the relevance of energy engineering to everyday life.


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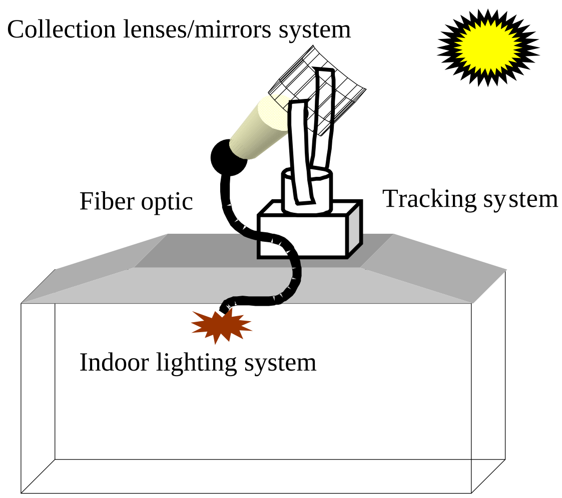


Figure 1: Schematic of the passive lighting system

Over the past two summers, the research topics have been broadened to increase recruitment of non-electrical engineering students and to appeal to the individual interests of the participating students. Students have selected projects in such areas as developing and testing:

- an electric field strength meter
- a solid-state device to detect magnetic fields
- a carbon monoxide detector for indoor applications
- a remote contamination (pollution) monitor for electrical insulators
- a position sensor for regulating pacemaker sleep mode
- an alarm system for HVAC air filters

The common theme of the research projects in the most recent summer was instrumentation.

3. REU Program Logistics and Daily Activities

The AISES chapter at ASU was enlisted to aid in the recruitment of students for the REU program. The REU program ran for eight weeks during the summer. The participants were provided with a stipend for the 40-hour per week time spent. The numbers of student participants was kept at a low level to afford greater personal interaction between the REU students and the normal project research personnel (*i.e.*, faculty, post docs, and graduate students). A half-time REU coordinator managed the day-to-day activities and logistics.

In the first week of each summer, students were given tours in all the participating laboratories and they were informed of the ongoing research projects. Students then spent a day or two researching (on the web and in the library) those topics most interesting to them. The intention


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was that by the end of the first week, the students were to have selected their projects from a menu of available research projects.

In addition to the REU project coordinator, student mentoring was provided by both faculty and graduate students involved in the specific research project. Mentors were responsible for providing daily supervision as well as directions to research material and guidance in laboratory safety. As the summer progressed and the students became more comfortable with their own project, and a greater level of autonomy was reached in their work.

Once or twice weekly a group meeting of the participants and mentors was held in which the students gave a short oral progress report on their project. These meetings not only exposed the participants to other research thrusts, but also served to develop their skills at critically evaluating the work of others. During the meeting, a brainstorming session typically took place that eventually provided various engineering solutions to the problems raised by the students. Otherwise, it was a reporting session in which students reported on the tasks and objectives achieved. Such meeting provided instantaneous managerial experience to the students in which the team spirit was steered toward the successful implementation of individual tasks.

Although the emphasis in the initial summer was one of hands-on, in subsequent summers students spent more time compiling a report of their activities. In the second summer students were encouraged to prepare a web page about their experience and the results of their project. Some of these reports are available at the project website at http://ceaspub.eas.asu.edu/nsfreu/. This option seems to be more attractive to the students than the preparation of traditional written reports. One further advantage of this approach is that future participants of the REU can easily access material describing the program.

Besides the direct research experience, the weekly activities of the students included attending seminars and field trips to local industry sites. Once a week a graduate student was enlisted to present a seminar of his/her research area to further broaden the REU students exposure to state-of-the-art developments. The field trips gave the students opportunities for interaction with individuals in industry. Some examples of sites visited include:

- Semiconductor manufacturing plant (clean room)
- Nuclear power plant
- Television studio
- Solar electricity generating site
- Energy (electric grid) control center
- Eco-building (a self-sustainable office building)

In addition, trips to less technical sites were conducted including tours of an art museum, a geology museum, and Frank Lloyd Wright's Taliesin West.


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4. Results

It was believed that the research and educational exposure at an early stage would serve to encourage underrepresented students to pursue science and engineering as a life-long career. A total of ten students have participated in the REU program over the past three summers. Table I shows demographic information on the REU participants, who ranged in age from 19 to 27. Some of these students have subsequently traveled to national professional meetings to present results of their research experience.[12,13] All of these students are presently in either a science or engineering major; specifically these students include engineering majors (bio, civil, computer, electrical and mechanical) and a chemistry major.

Table I: REU Participant Demographic Information

| Characteristic | Participant Data | |
|---|---|---|
| Gender | Female | 6 |
| | Male | 4 |
| Ethnicity | American Indian | 8 |
| | Caucasian (female) | 2 |
| Tribal Affiliation | Navajo | 7 |
| | Yaqui | 1 |
| Average Semester GPA | Semester Immediately Preceding REU Program Participation | 2.70 ± 0.59 |
| | Semester Immediately Following REU Program Participation | 2.73 ± 0.69 |
| Average Cumulative GPA | Preceding REU Program | 2.96 ± 0.50 |
| | Presently (March 2002) | 2.85 ± 0.45 |
| Average Credit Hours Earned | Semester Preceding REU Program | 12.5 ± 1.65 |
| | Semester Following REU Program | 12.4 ± 2.50 |
| Present Majors | Bioengineering | 1 |
| | Chemistry | 1 |
| | Civil Engineering | 1 |
| | Electrical Engineering | 5 |
| | Mechanical Engineering | 2 |

Although the present retention of the students is 100%, additional time is required to track whether the participants complete a technical degree. In the meantime, an analysis of the student's grade point average before and after participation in the REU program was conducted. The purpose of examining the GPAs at this point in time was twofold. The subsequent academic performance might indicate whether participation in the program (positively) affected the student's motivation and/or technical knowledge. Analysis found that on the average the student's cumulative GPA has dropped about 0.1 (on a scale of 0 to 4) since completing the REU


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program.  In addition, overall the student's semester GPA and number of earned credit hours for the semesters immediately preceding and following the REU program were found to change even less.  Given the number of students and the fact that some students have only attended one semester since completing the REU program, we consider these changes to be insignificant.

It was expected that this project would facilitate the involvement of American Indian students, increase the student retention and interest in the sciences and engineering.  At the same time the faculty and researchers have become more familiar with Native culture.  There is particular importance in this case for instructors from the 'majority culture' to know their students, how to motivate them, and how to retain them in engineering.

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Acknowledgements

The authors thank the National Science Foundation for its support of this program through grant EEC-96-96113.  The authors also acknowledge the mentoring efforts of Jose Montesinos and Ahmed Daoud in prior summers.




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