
AC 2011-185: COLLABORATIVE RESEARCH-MENTORING FOR TRIBAL COLLEGE STUDENTS

G. Padmanabhan, North Dakota State University

G. Padmanabhan, Ph. D., P.E., M. ASEE, F. ASCE is a professor of civil engineering at North Dakota State University, Fargo, North Dakota. He is a long standing member of ASEE and ASCE. Currently, he is also the Director of North Dakota Water Resources Research Institute. He has been active in STEM education outreach activities to minorities at the college and high and middle school levels for the last ten years.

Carol Davis, North Dakota EPSCoR

Dr. Carol Davis is a member of the Turtle Mountain Band of Chippewa. She helped establish Turtle Mountain Community College in the early 1970's and served as an administrator at the college for seventeen years. She received a doctorate in 2000 from Walden University. She currently works for North Dakota EPSCoR as the Tribal College Liaison. In that position, she is helping to create a pathway for American Indian high school and tribal college students into STEM careers through STEM camps and Sunday Academies. She also supports the ND EPSCoR/Tribal College research capacity building effort at the five North Dakota Tribal Colleges. She is on the Sisseton Wahpeton College Advisory Committee for their Tribal College and University Program grant funded by NSF. She also served on the American Indian Higher Education Consortium (AIHEC) advisory committee that developed the Indigenous Evaluation Framework published in 2009 and is often called upon by AIHEC to present at their STEM workshops. She still resides with her husband on the Turtle Mountain Reservation where she enjoys spending time with her family, especially her fourteen grandchildren.

Collaborative Research-Mentoring for Tribal College Students

Abstract

North Dakota's five tribal colleges and two research universities have been working together to establish smooth pathways and seamless transitions for Native American students who aspire to seek higher education degrees in Science, Technology, Engineering and Mathematics (STEM) by 1) creating a strong alliance between the universities and the state's tribal colleges; 2) implementing an initiative of research capacity building in tribal colleges that will engage tribal college faculty and baccalaureate anticipatory STEM majors in basic scientific research; and 3) engaging tribal college students in research using a tribal college-university collaborative model for research mentoring. Recent educational research has shown that students who engage in research projects are more likely to enroll in and complete STEM degree programs when compared to other students. Increased understanding of the research process, a shift from passive to active learning, enhanced research and laboratory skills, and increased understanding and interest in the discipline are some of the benefits undergraduate students gain by engaging in research. Therefore, "engaging the students in research" is adopted here as a major strategy to improve their retention in STEM programs. Faculty involvement in research mentoring not only leads to their enrichment as teachers but also enriches them as scholars. Though the responsibility of the tribal college (TC) faculty is primarily teaching, engaging in research and developing research project situations for students, research provides them opportunities to enhance their teaching capability and professional development. In this collaborative model, university and tribal college faculty co-mentor tribal college students on STEM research projects. One or two tribal college students work with a TC mentor and a university mentor. Students do research on their respective campuses during the academic year. The interaction of the university professor with the TC student and mentor is mainly over the telephone or with an occasional travel to campuses. The expectations are that the university and tribal college faculty members would help students develop the appropriate research questions (hypotheses) and would advise on techniques/methods of investigation, design of experiments, data analysis, drawing appropriate conclusions, preparation of presentations and reports of their findings. Imparting research skills is the emphasis of the collaborative research mentoring model and not necessarily discovery research. The collaborative model also creates a sound research platform between tribal colleges and universities. This paper will discuss the experience of the authors with this mentoring model from its conception, implementation, impacts, short-comings, successes, and finally the lessons learned.

Introduction

Although many outreach programs have components aimed at attracting more high school students into math, science and engineering programs, it is equally important to sustain their interest while in those degree programs to increase retention. One of the ways to achieve this objective is by providing research opportunities to those students. The related activities and experience will not only enrich their undergraduate experience but also motivate them to pursue graduate studies in those disciplines. Their career planning can benefit from such research experiences that help to focus on ideas and develop self-confidence about skills and abilities appropriate to science and engineering disciplines.

Recent educational research has shown that students who engage in research projects are more likely to enroll in and complete STEM degree programs when compared to other students¹. Increased understanding of the research process^{2,3,4}, a shift from passive to active learning^{5,6,7}, enhanced research and laboratory skills^{2,3,8,9}, and increased understanding and interest in the discipline are some of the benefits undergraduate students gain by engaging in research. Also in the last several years, the tribal colleges have been validating traditional tribal knowledge and exploring scientific concepts from Native perspectives. Embedded in this effort is a deep respect for traditional tribal knowledge and a desire to combine the Western notions of scientific methods and that of Native science concepts in the right proportions in order to create something that is academically rigorous and relevant to the needs of the contemporary tribal societies¹⁰. Integrating this approach in the research mentoring could especially be beneficial to motivate and retain tribal college students in STEM disciplines.

In this paper, the experience of the authors with an ongoing mentoring program to engage tribal college undergraduate students in research is discussed. In this collaborative mentoring model, university and tribal college faculty co-mentor tribal college students on STEM research projects. Unlike the other undergraduate research experience programs, in this model students do research on their respective campuses during the academic year. The expectations are that the university and tribal college faculty members would help students develop the appropriate research questions (hypotheses) and advise on techniques/methods of investigation, design of experiments, data analysis, drawing appropriate conclusions, preparation of presentations and reports of their findings. Imparting research skills, not necessarily discovery research, is the emphasis of the research mentoring model¹¹. Also, one of the needs of critical importance that might enhance the educational and career opportunities on the Reservations is to build research capacity of TCCs. Involvement of faculty and students in science and engineering research is likely to encourage students to pursue careers in science and engineering areas.

Collaborative Platform

As early as 1998, the institutional infrastructure for Native American students to seek careers in STEM at the North Dakota tribal colleges was beginning to take shape, but the students were not declaring STEM majors. This was becoming a concern at the tribal colleges. For example, Turtle Mountain Community College (TMCC) had more than 500 students but only 31 had declared STEM as a major. The situation was similar in the other four ND tribal colleges. This situation was the driving force for the five tribal colleges and the two research universities in the state to come together and explore ways to attract and retain Native American students in STEM disciplines. The tribal colleges had already received National Science Foundation Rural Systemic Initiative funds to enhance STEM programs on their campuses in 1998¹². Another 5-year grant from the Office of Naval Research (ONR) paved the way for a strong collaborative project¹³. A core group of faculty from the universities and tribal colleges worked together to conceive, design, and implement different STEM-enhancement activities for the tribal college and Reservation high and middle school students. This project with the participation of extremely dedicated faculty established a collaborative platform which is often the most difficult thing to accomplish. As the ONR funding ended in 2004, the North Dakota Experimental Program to Stimulate Competitive Research (NDEPSCoR) agreed to include the project in their proposal to the National Science Foundation (<http://www.ndsu.edu/epscor/NATURE/index.html>). The

project continued with the funding from NSF under the title Nurturing American Tribal Undergraduates in Research and Education (NATURE). Major activities under the project continued to be Sunday Academy¹⁴ and Summer Camps¹⁵. However, one of the lessons learned was that there was not enough focus on the NATURE students when they entered the tribal colleges and many were not being retained in STEM. While there were more than one hundred students participating in the high school programs and many enrolled in tribal colleges, they were not being retained in STEM programs at the tribal colleges. A review of published STEM retention data clearly shows that students who engage in research are more likely to be retained in STEM^{1,16,17}. This prompted the project team to initiate a research component in NATURE.

Research Component in NATURE

The student research mentoring component was added to NATURE in 2007 as a pilot program funded by the National Science Foundation Tribal College and University Program. It was later added as a component of NATURE by ND EPSCoR. The research component was formulated with two goals in mind. One was to retain the students in STEM programs and the second was to promote research capacity building at the tribal colleges. The first goal is of direct benefit to the students whereas the second one is general and applies to the tribal college faculty and STEM infrastructure. Primary responsibility of STEM faculty in tribal colleges is teaching. Though some are research oriented, some are not. Research capacity building in tribal colleges would involve training faculty to do research, developing supporting laboratory and other infrastructure, etc. The faculty would get involved in research if they could be convinced that research would help improve their instruction methods and materials. University faculty could provide this crucial link. A solid collaborative framework was already in place via NATURE. Therefore, a collaborative mentoring program was conceived as the next logical step and included in NATURE.

Collaborative Research-Mentoring Model

In this mentoring model one or two tribal college students are co-mentored by a university faculty and a tribal college faculty in their research project. Students do research on their respective campuses during the academic year. The interaction of the university professor with the TC student and mentor is mainly over the telephone, e-mail or with an occasional travel to campuses. The expectations are that the university and tribal college faculty mentors would help students to select research topics and develop the appropriate research questions (hypotheses) and advise on techniques/methods of investigation, design of experiments, data analysis, drawing appropriate conclusions, and preparing presentations and reports of their research findings. Imparting research skills is the emphasis and not necessarily discovery research. Students, tribal college faculty, and the university faculty work together in the entire process beginning with the formulation of the project to its completion and dissemination¹¹.

Co-mentors

Two STEM faculty from each tribal college received mentoring training. A workshop on research methodology was conducted for them as outlined in Ranjit Kumar¹⁸. Each mentor was provided a copy of the book by Kumar to use as a guide. The program provided for ten research

teams in each academic year. Each team consisted of two students, one tribal college faculty mentor and one university research mentor. Each of the selected tribal college STEM faculty was teamed with a university professor with research experience in the research topic area the student has selected.

The co-mentors were encouraged to introduce and apply native science concepts as appropriate in the research mentoring process. Students were encouraged to select reservation-relevant research topics. Major steps in the process included:

1. Introduce the idea of scientific research and general tools of research;
2. Examine the Native Science Perspective;
3. Develop meaningful student research projects;
4. Establish expectations of research experience to be provided;
5. Establish requirements for reports and presentations;
6. Provide research experience for students; and
7. Prepare students to present their research at conferences or at their home institution for other students and/or faculty.

Additional suggestions for tribal college mentors included:

1. Publicize to students the benefits of getting involved in research
2. Identify research opportunities (tribal college, NDSU, UND, industry, federal/state agencies).
3. Acquire necessary equipment and instrumentation
4. Determine whether or not to include the project in the curriculum or if it should be used as an enrichment activity for selected students only
5. Decide what measures will be used for evaluation

Native Science Concepts

Native people have understood that nature was not merely a collection of objects. Through stories, art and ways of community, Native tribes have expressed science as ever flowing and inseparable from our own perceptions with nature at the center¹⁹. They believe that everything has a spirit and everything is related. The tribal knowledge has provided a series of stories that described this belief. James Lovelock²⁰ explored this concept in his book, *The Ages of Gaia*, and argued from a scientific perspective that the earth was alive. The Gaia hypothesis and his evidence have provided a reference for environmental studies undertaken by tribal college students.

University and tribal college faculty together developed a document describing a procedure to formally address tribal culture in the research process. This guide was designed as an inclusive circular model that was a construct of the observations of the tribal college students and the world in which they live. This document could help students understand STEM through their cultural knowledge²¹.

Research Mentoring

While all students can be expected to benefit from participation in scientific inquiry, students selected for this program were the ones who would have declared a major in one of the STEM disciplines and possessed a minimum cumulative GPA of 2.5.

First, students were encouraged or guided to **select a topic** or problem of interest and relevance to them. Then they were required to conduct a **literature review** about their chosen topics. This included electronic and library archival research of scientific peer reviewed journals and other public sources. Next, students were mentored to obtain the necessary skills involved to state a hypothesis and alternatives, thus providing an opportunity to become familiar with the steps involved in a standard hypothesis testing procedure including confidence levels, null and alternative hypothesis, and acceptance intervals. Students clarified and determined the research questions (**hypothesis**). In the next step, students developed a written proposal of the **research methods** with activities and timelines. The plan included measurable and obtainable objectives. Students were encouraged to submit a written budget estimate with supplies, materials, and man-hours included. Also the plan included a data collection tool and information on what types of data would be collected, how it would be collected and analyzed for drawing conclusions. **Data collection and analysis** followed according to the plan. Then students **interpreted their results** and would **draw conclusions** in respect to their hypotheses. The last step was to **prepare a final report and a poster or PowerPoint** for presenting their research in a future conference or to the peers and faculty. The final report was to be approved by both the co-mentors. It included all information including why the student selected the topic, the hypothesis, data, interpretation of data, and conclusion. The students also provided a list of references for their work.

Students were encouraged to present their research results in conferences. The students and mentors were presented with certificates for completing research projects and also for presenting.

Reservation-relevant Research and Tribal College Research Capacity Building

The NATURE Coordinator on Cankdeska Cikana Community College (CCCC) campus and one of the NATURE faculty mentors on Turtle Mountain Community College (TMCC) campus currently teach a research skills course to introduce research thinking and skills to students. They use these courses to recruit students into the research mentoring program. Each tribal college is unique and each has progressed to different levels in building their research capacity. CCCC has examined their research initiative and chose this effort to help move their research capacity building forward. On each campus the selected mentors encourage and recruit students to participate in this research mentoring program.

Two full-time Fort Berthold Community College (FBCC) faculty are participating in this program to mentor student research. In 2009, the students examined mercury contamination in Lake Sakakawea, a man-made lake on the reservation. The student research project identified important baseline data completed 10 years ago by the state of North Dakota and another by Fort Berthold Tribe. This could be of great significance as FBCC prepares to participate as a research partner with National Ecological Observations Network (NEON), a climate change research center funded by the National Science Foundation. These environment-based initiatives reflect the deep interest that the FBCC community has for the environment and the close connection it has to the culture. Students often reflect that in their choice of research projects.

Research opportunities also exist to make significant contributions to understanding the native flora and fauna across North Dakota. For example, at TMCC, a very intriguing project to catalogue the different species of leeches is being carried out under NATURE research. The project is collaboration among TMCC, University of North Dakota, and faculty and students at Utah State University. Substantial progress in identifying new and diverse leech species has been realized through this collaboration. Beyond the impact of an improved understanding of biodiversity, these and similar efforts are helping to identify potential sources of novel biopharmaceutical agents that could prove useful in treating disease.

The environmental science degree curriculum at Sitting Bull College (SBC) includes a required project course. Participation in NATURE research is regularly accepted to satisfy the course requirement.

Stipends

NATURE provided stipends for the participating students and their co-mentors. The participants were all full-time students, full-time faculty, and/or full-time researchers. While the stipends were nominal, they were deliberately built into the program to demonstrate the value of this component. If students were expected to participate, the stipend was an incentive for them to meet research objectives. And, if co-mentors were expected to assist, the stipend was an incentive for them to guide the research to completion. Stipends were paid only after the student submitted a written report that was approved by both the co-mentors.

Spin Offs

The expectations were that the interaction between the university and the tribal college mentors was likely to lead to developing research proposals for submission to external funding agencies. Reservation-relevant research problems are being addressed through these proposals. Equipment and laboratory facilities are being shared. At least one tribal college faculty mentor received a REU grant from the National Science Foundation. Some others have submitted collaborative research proposals. One other pair of mentors is currently working on developing joint proposals. The mentoring program provided excellent opportunities for interaction between the tribal college and university faculty. Mentors invited each other and the students to visit their institutions and laboratories. In one or two instances the tribal college mentor and the student visited with the university mentor to get familiar with the operation of some special equipment.

Assessment

Since its introduction in 2007, about fifty student research projects have been completed. The first five cycles were semester-long projects. Suggestions from the mentors led to the introduction of year-long projects for the sixth cycle (Fall 2009-Spring 2010). The protocol was changed to require that the study progresses to the literature review at the end of the fall semester and concludes at the end of the spring semester with the submission of the final report. Three of the five tribal colleges offer environmental science degree programs. As a result, many of the NATURE research projects are environment-related.

Project titles can be viewed at:

<http://www.ndsu.edu/epscor/NATURE/research.html>

At the end of fall 2010 a survey of the university mentors, tribal college mentors, and students was conducted to obtain feedback for a formative assessment. Separate survey forms were developed for each constituency. Blanks of the three forms are appended. Overall, the collaborative mentoring model was considered good by both TC (5 out of 7) and university mentors (7 out of 10). However, there were concerns. Several suggestions have been made to improve the effectiveness of the model. It is important to recognize that some TC faculty mentors have Ph. D. degrees and have been engaged in research at the tribal colleges for a substantial period.

Mentors Feedback Suggestions for Improvement

1. Student and mentor recruiting: Review criteria for selection, stipend, and commitment of time and effort; designate or required project expertise dictate the mentors.
2. Communication of expectations: level of research to be expected. Not so much of discovery; but of research skills. Not the product but the process. This should be clearly communicated to the university and tribal college mentors.
3. Project duration: 2 years is typically a Masters Degree research. A one-semester course on research skills followed by a semester long project
4. Extending the program to include summer
5. Collaborative mentoring process: How to improve interaction between the co-mentors? Providing more opportunities for the university mentors to interact with students.
6. Role of university mentors: consulting as needed, active participation from the beginning to end, or only to review the reports? Is the requirement of the university mentor to “sign off” on the project necessary? On the other hand, the university mentors do not want to be involved only for “sign off”. It appears they want to be involved from beginning to end in all aspects of the project. They want a collaboratively produced and mutually acceptable project and report. “Mentoring” implies relatively constant contact with the student and the research project.
7. Funding: Project supplies and small equipment, research collaboration team’s visit to each other’s campuses, research seminars at each site providing opportunity for the students and mentors to present, etc. needs money. Include these items in the budget for research.
8. Feedback: Institute a procedure where the tribal college and university mentors comment at the end of the project on the process and make recommendations on future collaborations between co-mentors.
9. The tribal college mentors may spell out in advance of the start of the research any assistance/resources they may need.

Conclusion

North Dakota’s five tribal colleges and two research universities have been working together to establish smooth pathways and seamless transitions for Native American students who aspired

for higher education in Science, Technology, Engineering and Mathematics (STEM) by 1) creating a strong alliance between the universities and the state's tribal colleges; 2) implementing an initiative of research capacity building in tribal colleges that will engage tribal college faculty and baccalaureate anticipatory STEM majors in basic scientific research; and 3) engaging tribal college students in research using a tribal college-university collaborative model for research mentoring. Currently in its fourth year, the collaborative mentoring model is working very well. Participating students continued their quest to complete STEM degrees. The collaborative platform has also lead to fruitful interaction among the tribal college and university faculty to pursue long-term research collaboration.

NATURE encouraged research generated by students at the tribal colleges and facilitated a forum for research conversation between and among Native and non-Native faculty and Native students committed to research issues.

References

- [1] Peterson, M., Kraus, B. & Windham, T., 2005. Striving toward equity: Underrepresented minorities and mathematics. *Society for Industrial and Applied Math*, 38(3), Retrieved January 10, 2011, from SIAM: <http://www.siam.org/news/news.php?id=50>.
- [2] Alexander, B. B., Foertsch, J. A., & Daffinrud, S., 1998. Spend a Summer with a Scientist program: An evaluation of program outcomes and the essential elements of success. Madison, WI: University of Wisconsin-Madison, LEAD Center.
- [3] Foertsch, J. A., Alexander, B. B., & Penberthy, D. L., 1997. Evaluation of the UW-Madison's Summer Undergraduate Research Programs: Final Report. Madison, WI: University of Wisconsin, Madison, LEAD Center.
- [4] Alexander, B. B., Lyons, L., Pasch, J. E., & Patterson, J., 1996. Team Approach in the First Research Experience for Undergraduates in Botany/Zoology 152: Evaluation report. Madison WI: University of Wisconsin-Madison, LEAD Center.
- [5] Chaplin, S. B., Manske, J. M., & Cruise, J. L., 1998. Introducing Freshmen to Investigative Research— A Course for Biology Majors at Minnesota's University of St. Thomas. *Journal of College Science Teaching*, 27(5), 347–350.
- [6] Nikolova Eddins, S. G., & Williams, D. F., 1997. Research-based Learning for Undergraduates: A Model for Merger of Research and Undergraduate Education. *Journal on Excellence in College Teaching*, 8(3):77-94.
- [7] Schamel, G & Ayres, M., 1992. The Minds-on Approach: Student Creativity and Personality Involvement in the Undergraduate Science Laboratory. *Journal of College Science Teaching*, 21(4), 226-229.
- [8] Kremmer, J. F., & Bringle, R. G., 2000. The Effects of an Intensive Research Experience on the Careers of Talented Undergraduates. *Journal of Research and Development in Education*, 24(1), 1–5.
- [9] Kardash, C. M., 2000. Evaluation of an Undergraduate Research Experience: Perceptions of Undergraduate Interns and their Faculty Mentors. *Journal of Educational Psychology*, 92(1), 191-201.
- [10] Boyer, Paul (Ed), 2010. *Ancient Wisdom, Modern Science: The Integration of Native Knowledge in Math and Science at Tribally Controlled Colleges and Universities*, Published by Salish Kootenai College Press, Pablo, Montana and Distributed by University of Nebraska Press, Lincoln, Nebraska.

- [11] Padmanabhan, G. & Davis, C., 2008. Undergraduate Research Experience: A Collaborative Model for Tribal Community College Students, GC 2008-133, 7th Global Colloquium on Engineering Education, Cape Town, South Africa, Oct. 19-23.
- [12] Monette, G., 1995. High Plains Rural Systemic Initiative, NSF-RSI Award # 9554467 to Turtle Mountain Community College and Systemic Research Inc. NSF-RSI Key Indicator Report, 2004, Pages 74, 81, 82 and 86.
- [13] Davis, C. A., Padmanabhan, G., & Pieri, R. V., 1998. An Adaptive Systemic Initiative of Tribal Collaboration for Increasing Native American Participation in Mathematics, Science, and Engineering, Proposal funded by the Office of Naval Research, Arlington, Virginia under Grant No: N00014-99-1-0969.
- [14] Padmanabhan, G., Lin, W., Pieri, R., Patterson, F., & Khan, E., 2006. A Weekend Enrichment Program for Tribal High School Teachers and Students. Proceedings of the 2006 ASEE Annual Conference and Exposition, June 18-21, Chicago, Illinois, USA.
- [15] Lin, W., Padmanabhan, G., Pieri, R., & Patterson, F., 2007. Experience with and Lessons Learned in a STEM Summer Camp for Tribal College Students, 2007 ASEE Annual Conference and Exposition, Honolulu, Hawaii, June 24-27.
- [16] Education Resources Information Center, Institute of Education Sciences, Department of Education.
<http://www.eric.ed.gov/PDFS/ED509729.pdf>
- [17] Ishiyama, J., Miller J., & Nagan, M., 2006. Undergraduate Research and the Teacher-Scholar Model: A Curriculum Position Paper. August 15, 2006. Accessed on 07-25-10 via
http://provost.truman.edu/curriculum_papers/paper_Miller_Nagan_Ishiyama.pdf
- [18] Kumar, R., 2005. Research Methodology, A Step-by-Step Guide for Engineers, 2nd Ed., Sage Publications, London, UK.
- [19] Cajete, G., 2000. Native science: *Natural laws of interdependence*. Clear Light Publishers, New Mexico, USA.
- [20] Lovelock, J., 2000. The Ages of Gaia. A Biography of our Living Earth, Second edition, Oxford University Press, 255 pages.
- [21] North Dakota Experimental Program to Stimulate Competitive Research (ND EPSCoR), 2007. North Dakota Tribal College faculty Research Model: Guiding Undergraduate Student Research in Science, Technology, Engineering and Mathematics. Tribal College Liaison Program.
http://www.ndsu.edu/epscor/NATURE/Documents/NDTribalCollegeFacultyResearchModel_8-30-07_final.pdf