



UNIVERSITY OF
SOUTH DAKOTA



South Dakota State University

SOUTH DAKOTA



SCHOOL OF MINES
& TECHNOLOGY



IGERT

**SOUTH DAKOTA
INTEGRATIVE GRADUATE
EDUCATION & RESEARCH
TRAINEESHIP PROGRAM
(IGERT)**

**PROGRAM EVALUATION
ANNUAL REPORT**

SPRING 2016

INTRODUCTION

The South Dakota Integrative Graduate Education and Research Traineeship (IGERT) program received a no-cost extension for 2015 – 2016. The purpose of this report is to summarize the annual evaluation efforts. Feedback and insights from IGERT trainees, faculty, and administrators were objectively assessed so as to inform programmatic effectiveness and set a platform for the measurement of long-term outcomes. Fourteen (14) current and former students and six (6) faculty participated in surveys and interviews. The three participating universities are University of South Dakota (USD), South Dakota State University (SDSU), and South Dakota School of Mines and Technology (SDSM&T). Three (3) students began the program in Summer 2016.

The primary research questions for the 2015 - 2016 annual report were:

1. What program elements should the participating universities carry forward in similar proposals? (Students and Faculty)
2. What program elements should be improved or added? (Students and Faculty)
3. What factors increased persistence to pursue a science and/or engineering degree in high school? College? Graduate school? (Students)
4. What are the barriers that prevent American Indian students from attending graduate school, particularly in science and engineering?

The Principal Investigator, Program Coordinator, and external evaluator are preparing the comprehensive final report which will address each element of the logic model including but not limited to the status of each student and research outcomes.

PROGRAM STRENGTHS

By design, the IGERT program aims to educate U.S. Ph.D. scientists and engineers with deep understanding and knowledge of their chosen discipline, provide interdisciplinary training, and instill technical, professional, and personal skills that foster leadership and position those scientists and engineers as creative agents for change in their careers. IGERT also aims to catalyze a cultural change in graduate education by establishing innovative models for graduate education and training in a fertile environment for collaborative research that transcends traditional disciplinary boundaries.

The South Dakota IGERT program provided interdisciplinary training in materials chemistry, electrical engineering, nanoengineering, and chemical engineering. This unique technical training along with outreach opportunities which honed communication and project management skills produced Ph.D. candidates with well-rounded skills. The skillsets prepared them for academia, government and industry careers. A comprehensive list and analysis of program elements will be listed in the final report. The following program components and benefits were noted as the most positive and impactful attributes of the project in the 2015 – 2016 survey and interviews. The list is ranked from most popular response to least. The participating faculty reviewed the list below and agreed with the conclusions.

STRENGTHS AND BENEFITS

Campus rotation. The students with advisor input develop a research plan in which a period of time is spent at a partner university laboratory. Both students and faculty indicated the campus rotations were unique to the IGERT program and were very productive. Graduates indicated that the research conducted during the campus rotation

contributed 10% - 50% to their thesis. Although some students did not have a successful rotation, most did. The three new students did not have an opportunity to do campus rotations. (6 students)

Outreach activities. Students organized and participated in a variety of outreach experiences with little assistance from their faculty advisors. Although most outreach experiences were coordinated and executed with two or more students, some projects were conducted by a single student. Laura Kuschel, IGERT coordinator, was instrumental in working with the students to coordinate outreach activity logistics. Both students and faculty noted the benefits for the students were greater communication, project management, and time management skills. For those who taught courses at small colleges and community colleges, the teaching experience as the primary instructor (versus a teaching assistance position) was invaluable in providing teaching experience and validating their career aspirations of entering academia. Those students that team taught at Nebraska Indian Community College had the most positive reviews. (6 students)

Interdisciplinary courses. Although the universities are considerably distant from each other (>350 miles), the Access Grid – a video conference system that ties the three universities – facilitated interdisciplinary courses. This system was leveraged from a previous grant. One out of two students noted the interdisciplinary classes via the Access Grid was a strength and a favorite aspect of the program. They believed the courses broadened their education background, provided theoretical basis for research projects, and a venue to get to know faculty and students outside their home institution. The faculty and administrators are confident that they will be able to maintain interdisciplinary courses. (4 students)

Collaborative interdisciplinary research. IGERT expanded research into new areas that would not otherwise be possible. The students concluded scientists and engineers make great teams and the SD IGERT Program afforded the students to enrich their training and dissertations. The research resulted in several publications and presentations as listed in the annual reports. A majority of the faculty members feel that IGERT enabled them to establish work with colleagues in other departments and exposed them to new ideas and research techniques resulting in grant awards. Findings from the evaluation suggest that IGERT projects are helping advance interdisciplinary graduates education in their institutions. (4 students)

Professional Conferences. The professional conferences provided a valuable venue to attain new ideas and network with people in their field. This past year 8 out of 9 students and one former affiliate student attended conferences. Conferences included:

- Materials Research Society National Spring Meeting 2016
- American Chemical Society National Spring Meeting 2016
- Sanibel Symposium 2016
- Pacifichem conference 2015 (International Chemical Congress of Pacific Basin Societies)
- North Dakota State University Symposium
- American Chemical Society National Fall Meeting 2015
- Digital Fabrication and Digital Printing Nip31 Conference Fall 2015

Additionally, students from the South Dakota IGERT program and Arizona State University IGERT program hosted a student run symposium titled "Harnessing the Power of Solar (Materials & Processes: Renewable Energy from Solar)". Seven (7) of the 9 current IGERT students and one former affiliate student attended this conference. One of the South Dakota IGERT students was primarily responsible for organizing the event, with some assistance from IGERT members at ASU. There were 8 speakers from universities and national labs and 2 IGERT student speakers. Along with the full-day conference, all of the ASU and South Dakota IGERT students presented posters at the poster session; two of which were nominated for best poster.

Stipend. All of the stakeholders noted the stipend was instrumental in keeping students on track to completing their Ph.D. program.

The above elements have been incorporated in current and pending grant proposals as Principal Investigators have recognized the value of the components in increasing student and institutional capacity. The South Dakota IGERT program has also allowed collaborations across the three campuses that have fostered additional projects.

OPPORTUNITIES FOR IMPROVEMENT

Although most of the feedback was largely positive, faculty and students did provide some suggestions. The following are suggestions when designing a future, similar program:

Industry and National Laboratory Internships. Initially, program leaders were planning to provide IGERT students with opportunities with national energy laboratories and industries. However, partnerships with industry and labs did not come to fruition and internships did not materialize. The students who were involved early in the program indicated they would have taken advantage of an internship opportunity if available. When designing future similar programs, determine if internships should be an option or just focus on cross campus rotations. (5 – students, 1 – faculty)

Annual Review. When the students first joined IGERT they created a proposal which listed goals. Students suggested having an annual review with the IGERT coordinators as well as their advisor to ensure they are on track with the original and take necessary interventions if necessary. (4 students, 1 faculty)

Many graduate students, myself included, often get side tracked in the details of a project. Designing a program that sticks to a realistic timeline and helps students evaluate when to move on or keep hammering away would be a big asset. I like the idea of students needed to reorient themselves by resubmitting a proposal every year to keep the IGERT funding (new proposal will be updated with new results, goals and possibly new solutions if old ones didn't work).

Campus Rotation Expansion and Collaboration. Campus rotations were offered between USD, SDSU, and SDSM&T pending acceptance of research project collaboration. Most students had successful rotations; however, a few students expressed interest in rotating at campuses in other states where their research interests are more closely matched with their own projects. On the other hand, one student said their project would have been better aligned with another advisor at their home institution. (2 students, 1 faculty)

The proper and feasible collaborative project design is a key for the success of the project in which helps to achieve the maximum output.

Broad Research Area. For future, similar proposals, it was suggested to include broad topics that do not limit areas of research and encourage science and engineering collaboration. Suggestions included solar electricity, batteries, and water treatment. (2 students, 1 faculty)

PERSISTENCE

A critical component of the South Dakota IGERT project was recruiting students to participate in the program. The final report will further outline student recruitment, retention, and outcomes. During the 2014 – 2015 evaluation interviews, the IGERT students began to share with the external evaluator the factors that influenced them to persist from high school through post-doctoral fellowship in science and/or engineering fields. In this report and the final report, areas of persistence were further explored.

Research by Maltese and Tai (2011) has shown the presence and absence of significant association among many important factors related to persistence in attaining a bachelor degree in a STEM field. Those factors include:

- Students who in 8th grade indicated that they were interested in a science career.
- Students who completed geometry, biology, chemistry, trigonometry/Algebra II and calculus.
- High school seniors who indicated a major in a STEM field.
- College freshmen who complete more STEM credits in their first year.
- College freshmen who earned strong marks in STEM courses.

Of the above factors, the most prevalent factor was high school seniors who indicated a major in a STEM field. These students were more than three times as likely to earn a STEM degree as those who were planning for a different major at that time. The major students have in mind when leaving high school is a strong predictor of their eventual degree field. A finding supported by research on college freshman (Astin & Astin, 1993, Bonous-Harnmarth, 2000). The Maltese and Tai research provided encouragement that parents' education level and students' involvement in loan programs and work-study were not significant.

Students that had a lesser chance of completing a STEM degree indicated the following factors:

- Failed one or more college courses.
- Had a child prior to completion of their degree.
- Reported frequent use of computers in K-12 mathematics classes.

For the ***South Dakota IGERT students***, the following factors influenced them to persist through their academic career. Those factors that are bolded and italicized were consistent with the literature review. For the final report, the external evaluator is conducting a literature search for graduate persistence in STEM fields. Most research in this field is primarily focused on high school and undergraduate students.

HIGH SCHOOL to BACHELORS PERSISTANCE

- Completed key classes:
 - o ***Chemistry***
 - o Physics
 - o ***Biology***
 - o ***Calculus***
 - o Drafting / AutoCad
- ***Enjoyed science and math classes.***
- ***Received high grades in science and math classes.***

BACHELORS PERSISTANCE

- ***Completed science and math classes during first year.***
- ***Interested in subject area and declared degree.***
- Participated in undergraduate research during the academic year and/or summer research programs
- ***Identified themselves as a scientist and/or engineer through research and program progress.***

GRADUATE PERSISTANCE

- Declared interest in careers that require Masters or Ph.D. such as university research and teaching.
- Received stipends and scholarships that cover some or all expenses of tuition and living expenses.
- Desired industrial positions, particularly in Research and Development, required a Masters or Ph.D.
- Influenced or encouraged by professors and graduate advisors

It is important to note that three of the IGERT students interviewed would not have pursued Ph.D. degrees without the support of the IGERT program, particularly the support of the stipend and the encouragement of their IGERT advisor.

The three universities are employing several strategies to increase retention and persistence from high school to graduate school in STEM fields. Three examples are outlined below.

- **NSF Career Grant Design.** Dr. Sun, USD Chemistry, has designed his NSF Career grant to create a pipeline of high school students interested in science. In 2015 and 2016, he recruited high school students to work in his lab the summer before their senior year. His requirements were high marks in science and reading and an indicated interest in science during a college visit. The students read and discussed scientific journal articles with Dr. Sun and completed meaningful lab work. Both students participating in the 2015 summer research will be attending USD in Fall 2016 with declared majors of Biochemistry and Chemistry.
- **SDSM&T MathSpark Program.** The State of South Dakota has allocated \$250,000 for the SDSM&T MathSpark mathematics summer bridge programming for incoming college students. SDSM&T found that students drop out of engineering programs primarily due to lack of math preparation. Tests so far indicate better overall math scores by those in the MathSpark program. Funding pays for lecturers, graduate assistants in math labs, mentors, a program director and evaluation.
- **Undergraduate Research Programs.** Undergraduate research has been an important factor that has influenced students to pursue graduate studies. The three South Dakota universities have several undergraduate research programs, most notably NSF REU programs, that recruit students within and outside the state.
- **Graduate Research Programs.** Stipends from graduate research programs afford students the opportunity to finish their graduate degrees without going deeply into debt. The stipend is particularly important to attract engineers as bachelor-degreed engineers are highly employable at attractive starting salaries.

AMERICAN INDIAN TARGET AUDIENCE

Many South Dakota undergraduate and graduate programs, including the South Dakota IGERT program, have a goal to recruit American Indian (AI) students into the program. South Dakota's AI population is 8.9% of the state's total population (2014 U.S. Census). Few programs reach their AI recruitment goal. This subject will be further vetted in the final report to include statistics and further evidence of root causes and potential solutions. For the annual report, the evaluator asked the faculty for their observations. The following were their observations:

- The population of South Dakota university AI students is small. Therefore the pool of students that matriculate from bachelor programs and graduate programs is small.
- Some students did not receive proper K-12 preparation so may require bridge programming to succeed in the university environment.
- Some students from tribal colleges may require bridge programming to go into university science and math curriculums
- Some students are reluctant to move out of their communities for long periods of time. In order to complete a bachelors, masters, and Ph.D. program, the student would need to move to one of the campus communities for 10 – 12 years.
- Some students do not see the value of a graduate degree versus a bachelor's degree only.

The Maltese and Tai research found a negative association between both female and AI students and a degree in STEM. The researchers who followed students longitudinally from 8th grade through bachelors completion calculated an odds ratio of AI students completing a STEM degree at 0.21 at 8th grade, 0.27 at 10th grade, and 0.31 at 12th grade and 0.60 while enrolled in college.

At the three South Dakota IGERT universities in 2014, AI students comprised the following percentages of the student enrollment: 1.79% - SDSM&T, 1.67% - USD, and 1.01% - SDSU. At SDSM&T the student retention was 31% at Year 4, the lowest of all ethnic minorities.

South Dakota universities have implemented several strategies within their multi-cultural and diversity offices to address AI student recruitment and retention. South Dakota public universities have implemented the *South Dakota Jump Start* program, a federally funded program designed to help AI and low-income students succeed in college by providing them financial and academic assistance.

Specifically, the South Dakota IGERT program conducted outreach programs including the GEAR-UP program that targeted middle and high school AI students on the SDSM&T campus. The USD IGERT students team taught courses at the Nebraska Indian Community College (NICC) chemistry courses. The students who participated noted this particular outreach experience was extremely valuable to their academic experience and provided them insight to an academic career. NICC echoed praise of the program. A potential future project would be to have graduate students teach at tribal colleges and/or provide bridge programming to transition to the universities to finish their bachelor degrees.

In summary, strategies to increase persistence in high school and college should be monitored to determine the most effective strategies. In the interim, grant programming goals may consider expanding recruitment targets to include all underrepresented populations including AI students.

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