



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

SPRING 2015

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Choumini Balasanthiran

Ying Bao

Braden Bills

Jon Fisher

David Galipeau

James Hoeflemeyer

Amy Hor

Abdulmenan Hussein

Stephanie Jensen

Ranjit Koodali

Brian Logue

QuocAnh Luu

Luther Mahoney

P. Stanley May

Hank Miller

Jeff Mottishaw

Nathan Netzer

Jacob Peterson

Jan Puszynski

Jim Rice

Uma Sambasivam

Logan Sanow

Haoran Sun

Andrew Sykes

Sem Tamang

Bjorn Vaagensmith

Dasha Weatherman

Zhiling Zhang



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EXECUTIVE SUMMARY

A comprehensive evaluation plan was launched following the implementation of the National Science Foundation's (NSF) Integrative Graduate Education and Research Traineeship (IGERT) program in South Dakota. The South Dakota IGERT Program is led by Principal Investigator Dr. Mary Berry (University of South Dakota). 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. The evaluator interviewed 35 students, faculty, and administrators from the three participating universities: University of South Dakota (USD), South Dakota State University (SDSU), and South Dakota School of Mines and Technology (SDSM&T). In addition, the Nebraska Indian Community College science program representative was interviewed as a significant outreach program was focused on developing and facilitating chemistry courses for them.

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. These two tenets and overarching goals of NSF relative to IGERT are further outlined below, with comparative data from this evaluation as noted relative to IGERT students and the IGERT experience.

1. **Providing a broader, diverse education to Ph.D. Scientists and Engineers.** NSF expects that IGERT projects will educate students to work in an interdisciplinary environment while being well grounded with depth of knowledge in a major field. The IGERT experience should contribute to the professional and personal development of graduate students and equip them to understand and integrate scientific, technical, business, social, ethical, and policy issues in order to confront the challenging problems of the future. Students should receive experience relevant to both academic and nonacademic careers.¹

IGERT Students

receive more extensive interdisciplinary training than traditional graduate students, yet maintain depth of study in their chosen fields.

report greater opportunities to learn about other disciplines through interaction with faculty and students, and through collaborative work on multi-disciplinary projects.

are better prepared to work in multidisciplinary teams and communicate with people outside of their own fields.

receive greater training in teamwork, presentation methods and style, and communication skills.

report feeling better prepared for their future professions.

¹ *Evaluation of the Initial Impacts of the National Science Foundation's Integrative Graduate Education and Research Traineeship Program.* Abt Associates Inc. February 2006.

The IGERT Experience

provides broad career exposure.

provides students with significantly broader professional and personal skills for their future careers.

fosters interaction between participants and others outside of their home institutions.

fosters interaction between participants and others outside of academia.

2. **Cultural Change in Graduate Education.** A longer-term goal for the IGERT program is to catalyze a cultural change in graduate education, resulting in faculty and institutional support for interdisciplinary graduate education. IGERT has been successful in promoting a fertile environment for faculty to engage in interdisciplinary teaching and research. IGERT faculty members report that participating in IGERT has enabled them to teach a greater variety of students and incorporate a broader range of topics in courses. With respect to interdisciplinary research, more IGERT faculty publish and present their research in journals and conferences from outside their primary disciplines of study, and are more likely to work on research projects and co-author publications with colleagues from other disciplines as a result.²

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, new research techniques, and new grant opportunities. Findings from the evaluation suggest that IGERT projects are helping advance interdisciplinary graduates education in their institutions.

Additionally, the Access Grid – a video conference system that ties the three universities – facilitated interdisciplinary courses. This process will continue post-award. The faculty and administrators are confident that they will be able to maintain infrastructure benefits beyond the project period, particularly interdisciplinary courses, research projects, and grant projects.

Overall, the South Dakota IGERT program has had a transformative benefit to the trainees (students) and faculty. The response from all stakeholders was overwhelmingly positive. The 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 both academia and industry careers. The following program components and benefits were noted as the most positive and impactful attributes of the project: The list is ranked from most popular response to least.

STRENGTHS AND BENEFITS

Interdisciplinary courses. Although the universities are considerably distant from each of us (>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.

² *Evaluation of the Initial Impacts of the National Science Foundation's Integrative Graduate Education and Research Traineeship Program.* Abt Associates Inc. February 2006.

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.

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%. Although some students did not have a successful rotation, most did. During the interviews, the external evaluator asked those students who indicated they had a positive and productive campus rotation what the key success factors to a successful campus rotation. The following suggestions were provided:

- Allow time to collect enough data during the campus rotation. Those who expressed satisfaction with the rotation spent the entire summer or semester at their host campus.
- Get to know the students and the faculty from the host institution via the Access Grid, conferences, e-mail, phone calls, etc. prior to the rotation.
- Plan the experimental designs in advance and ensure everything is in place (materials, supplies, equipment) prior to arriving.
- Arrange passwords, keys, and other logistical items as much as feasibly possible prior to rotation.
- The host advisors carved out time during first week to teach instrumentation and ensure factors are in place for success.
- Communication was key. If there was not a good communication between groups then the rotation seemed to hinder, but if there was good communication then the rotation thrived.

Collaborative interdisciplinary research. IGERT expanded research into new areas that would not otherwise be possible. Nearly every interview resulted in the sentiment that 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.

Cohort. Students, faculty, and administrators noted the many benefits of the cohort developed during the grant period. Specifically, they noted leveraging the strengths of the South Dakota regental system and collaborative research. They appreciated the networking opportunities afforded during the symposiums, conferences, and outreach activities. And finally, life-long friendships have been forged across campus lines.

Career Choice: Again, the IGERT program prepares Ph.D. candidates for both academia and industry. Although some IGERT students are on the career path they originally envisioned when entering the program, other students have been influenced to alter their plan based on their IGERT experience. In some cases, IGERT validated their career choices.

Mentoring and advising. Every student noted their home institution advisor had a profound effect on their academic career. Some students provided specific examples of how their campus rotation advisors impacted their research project, career paths, and philosophy. ***Please note specific faculty are noted favorably in the quotes within the body of the report. However, all faculty had positive reviews.***

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

Governance structure. The IGERT student-led governance committee met on a monthly basis. Agendas included external speakers, outreach coordination, symposium coordination, and other overall coordination activities. The meetings were facilitated on the Access Grid and provided the students an opportunity to get to know and interact with each other.

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. Seven students 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.

Foreign Students. The IGERT program was designed for U.S. citizens. The affiliates who participated along with a few of their U.S. citizen peers expressed they wished future grants would provide stipends for foreign students in order to attract best candidates, regardless of citizenship.

Campus Rotation Expansion. 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.

Campus Rotation Planning. The students who did not have a good rotation noted one or more barriers including: a) host advisor did not interact with the student; b) not enough time at host campus; and c) logistics (passwords, keys, etc.) were not planned or ready prior to student arrival.

Annual Review. When the students first joined IGERT they created a proposal which listed goals. A student 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.

SUMMARY

This evaluation finds that doctoral students participating in IGERT projects receive different educational experiences than they would have if they were in a single disciplinary degree program. IGERT was successful in providing a vehicle in South Dakota graduate education, both by providing interested faculty members with a vehicle to engage in interdisciplinary activity, and in developing alternate models of education that have been adopted by programs within the SD IGERT institutions. IGERT students report they are better prepared for academia and industrial careers. The universities have developed interdisciplinary courses that will be continued to be delivered via the Access Grid. The faculty have been successful in leveraging the IGERT collaborative interdisciplinary research to additional grant-funded projects to further their research.

unately, the IGERT faculty had worked together previously through the Photo Active Nanoscale Systems (PANS) Research Group which included over forty faculty, research staff, graduate and undergraduate students from five institutions of higher education in the State: Augustana College, Black Hills State University, South Dakota School of Mines & Technology, South Dakota State University, and the University of South Dakota. Project participants in the PANS Research Group created new devices in the area of photo-active nanoscale systems and continue to address research challenges associated with photovoltaics and solar energy, Direct-Write electronics, and the use of nanostructured materials for converting solar energy into chemical fuels.

Through this statewide collaborative effort and central to the vision for PANS, participating faculty were able to work out the kinks associated with this type of interdisciplinary and multi-institutional work; everything from connectivity, ability to network, and collaborative design of experiments through a virtual research and educational community was addressed. These activities, along with the validation of cyber-enabled content delivery and shared information resources as part of the National Science Foundation/SD EPSCoR Grant have positioned South Dakota universities for future collaborative efforts.

The EPSCoR Program has successfully built a research infrastructure in South Dakota, and as a result has positioned participating institutions to be



competitive for other federal grants, particularly through NSF. These SD-institutions sought to leverage the EPSCoR award and ultimately were awarded a host of grants to support this aim; participating faculty were and still are expected to actively pursue federal programs for students and faculty, including but not limited to CAREER, IGERT, and REU. Beings that the research activities and network of scientists were and remain distributed among the regental institutions and other private and tribal institutions in SD, the strategy for growth in external funding support relied on that very collaboration to be successful. In comparison, the number of participating faculty and research infrastructure formulated by EPSCoR is collectively the size of a larger institution (e.g. Iowa State University) on its own. Together, these SD-based institutions are far stronger than they would be as individually competing organizations. The pursuit and successful award of an IGERT program is a primary outcome of the EPSCoR funding and infrastructure in place, and served to fill a void in graduate student population in the State that may not otherwise have been mitigated.

METHODS

During the first years of the program Dr. Stuart Kellogg of SDSM&T evaluated the program impacts on the students using surveys and interviews. Dr. Kellogg was not able to finish the evaluation so Dr. Mary Berry, PI, engaged Sage Project Consultants, LLC (Sage) to complete the evaluation. Laura Ann Kuschel, IGERT program coordinator, created a list of all of the IGERT trainees and associates, key faculty members, and administrative representatives from USD, SDSU, and SDSM&T. Sage developed interview instruments for each target audience based on experience with other graduate and undergraduate programs as well as the questions developed by Abt Associates Inc. captured in the IGERT meta-analysis published in February 2006.³

Sage researchers traveled to USD and SDSU to interview students, faculty, and administrators face-to-face. Due to illness of the primary evaluator, the SDSM&T interviews were conducted over the telephone with follow-up and clarifying questions conducted via e-mail. For those students that had graduated from their respective Ph.D. programs, Sage conducted either face-to-face, telephone, or e-mail interviews. Of the original list, 87% (21 of 24) of students were interviewed, 100% of faculty, and 100% of administrators.

The interview comments were de-identified and themed for each question. The interviews were analyzed for themes and the number of respondents (students) who identified the theme is listed in parenthesis. Quotes that represented feedback are listed under some themes and are italicized. Some respondents listed two or more themes under each questions so the sum of respondents may be greater than the number of individuals interviewed. The report that follows is a summary of the findings from each question.

The IGERT project team and evaluator will meet to review the formative results in order to make interventions and reinforce practices that further goals and objectives. The South Dakota IGERT program was approved a one year no-cost extension. A final evaluation and meta-analysis will be conducted Spring 2016.

³ *Evaluation of the Initial Impacts of the National Science Foundation's Integrative Graduate Education and Research Traineeship Program.* Abt Associates Inc. February 2006.

PROGRAM GOALS

1. Implement a new model for small graduate programs in rural States to develop influential, collective, interdisciplinary graduate programs capable of high-impact contributions to research and workforce development in critical areas.
2. Confer degrees to ten (10) students per year and place graduates and affiliates in postdoctoral appointments, university faculty positions, national laboratory staff positions, solar industry, or as entrepreneurs.
3. Recruit ten (10) new B.S. or M.S. level students into the program each year.
4. Enroll, graduate, and place Native American students in proportion to their representation with the state of South Dakota. This will represent an order of magnitude increase in Native American enrollment in STEM graduate programs in South Dakota.
5. Students in the program will produce at least six (6) technical articles and journal publications per year in nationally recognized outlets for nanostructured solar cells, materials, process, and devices.
6. Student self-efficacy and persistence as measured by progress towards graduation will increase with enhanced opportunities to conduct independent large scale research projects in a collaborative and interdisciplinary environment.
7. The program will support a K-16 education outreach project. K-12 demonstration and laboratory projects will meet South Dakota Science Standards and will be evaluated for both impact and usability.

PROGRAM LOGIC MODEL

The South Dakota IGERT logic model was used to ensure the inputs and activities of the program resulted in the required outputs, outcomes, and impacts. Formative evaluation results are intended to guide programmatic interventions.

Inputs	<ul style="list-style-type: none"> ▪ NSF IGERT funding and program support ▪ Institutional (USD, SDSU, SDSM&T) support including classroom use, laboratory infrastructure and multicultural programming support ▪ IGERT faculty ▪ IGERT graduate students
Activities	<ul style="list-style-type: none"> ▪ Recruit 10 new B.S. or M.S. level students into the program each year. ▪ Recruit Native American graduate students into the program. ▪ Offer an interdisciplinary course to broaden student knowledge base. ▪ Rotate and expose students to campuses outside their home university. ▪ Work with industry and government partners to place IGERT students in internship positions. ▪ Coach students to prepare technical articles and journal publications. ▪ Prepare and facilitate outreach activities for K – 16 education outreach.
Outputs	<ul style="list-style-type: none"> ▪ (Number) of students in program each year ▪ (Number) of students graduating from the program ▪ Research progress and outcomes ▪ Presentations ▪ Publications ▪ Grant applications ▪ K-16 outreach efforts
Outcomes	<ul style="list-style-type: none"> ▪ Increased non-minority and minority students entering graduate chemistry disciplines ▪ Graduates with background in solar energy technology to develop innovative and cost-effective solutions. ▪ Competitive graduates successful in gaining employment in industry or academic settings.
Impact	<ul style="list-style-type: none"> ▪ Pipeline of Chemistry Masters and PhD scientists into industry or academic settings. ▪ Creative scientists solving interdisciplinary problems, particularly in the solar energy industry.

EVALUATION METHODS

These methods were used to evaluate the program, and were vetted through meetings and discussions with IGERT program directors and administrators prior to use.

#	Goal	Method/Component	Responsibility	Timeline
1	1 - 7	Logic model	Sage Project Consultants	Initial draft: complete Review and update within 2 months of award and annually thereafter
2	2 - 4	Student recruitment and retention	IGERT Program Coordinator	Throughout project period
3	1 - 7	Student attitudinal and feedback interviews. (All IGERT and Affiliate students; ~19 interviews)	Sage Project Consultants	March annually
4	1 - 7	Faculty feedback interviews (~15 interviews)	Sage Project Consultants	March annually
5	1 - 7	Administration feedback interviews	Sage Project Consultants	March annually
6	1,2,5,6	Research Outcomes	IGERT Program Coordinator	May annually
7	1,2,5,6	Educational Outcomes	IGERT Program Coordinator	May annually
8	1,2,5,6	Trainee Achievements	IGERT Program Coordinator	May annually
9	7	Outreach Activities	IGERT Program Coordinator	May annually
10	1 - 7	Partnerships/Collaborations	IGERT Program Coordinator	May annually
11	6	Longitudinal Alumni Outcomes	Sage Project Consultants	March annually through project period
*	1 - 7	2014-15 Formative Report	Sage Project Consultants IGERT Program Coordinator	April 2015
*	1 - 7	2015-16 Formative Report and Summative Report	Sage Project Consultants IGERT Program Coordinator	April 2016

RESEARCH & ANALYSIS OUTLINE

The design of the evaluation plan, specifically the survey instruments, was informed by NSF evidenced based evaluation design methodologies. Specifically, elements from the Student Assessment of their Learning Gains (SALG) (<http://salgsite.org/about>) and the Abt Associates 2006 Report titled Evaluation of the Initial Impacts of the National Science Foundation's Integrative Graduate Education and Research Traineeship Program (http://www.abtassociates.com/reports/INC-ALL-2-06_IGERT.pdf) were adapted or adopted in this evaluation plan design.

The following provides additional detail on the evaluation methods identified above, and includes narrative where appropriate to provide additional explanation.

[1] Logic Model. The logic model methodology was based on The Logic Model Guidebook (Wyatt Knowlton, 2013). Also referred to as a program matrix, logic models are tools that can be used to evaluate the effectiveness of a program, examining logical relationships between resources (inputs), activities, outputs, and desired outcomes. Theoretically, the logic model allows the evaluator and program managers to causally assess the “if-then”

relationship between elements of a program; for example, if certain resources are available, then certain program activities can happen, and if those activities are implemented successfully then certain outcomes can be expected.

[2] Student Recruitment and Retention. The goal of the IGERT program is to increase the number of trainees from South Dakota and the region including Native Americans. The coordinator regularly tracks demographics and other relevant data of applicants, those students who were accepted, and those retained in the program. Data tables were generated for tracking purposes to capture baseline data and data resulting from the intervention of the IGERT program.

[3] Student Attitudinal and Feedback Interviews. All IGERT and Affiliate students were interviewed in March and April 2015. Results were summarized by Sage and provided to the coordinating team. The coordinating team and evaluator will meet in June 2015 to review the student interview report in order to make interventions and reinforce practices that further the goals and objectives. Specific questions asked are featured in the data summary of this report.

[4] IGERT Faculty Feedback Interviews. IGERT faculty were also interviewed in March and April 2015. Results were summarized by Sage and provided to the coordinating team. The coordinating team and evaluator will meet in June 2015 to review the faculty/mentor interview report in order to make interventions and reinforce practices that further the goals and objectives. Specific questions asked are featured in the data summary of this report.

[5] USD, SDSU, SDSM&T Administration Feedback Interviews. Administration (one representative from each institution) were interviewed in April 2015. Similar to student and faculty interviews, results were summarized by Sage and provided to the coordinating team. The coordinating team and evaluator will meet in June 2015 to review the administration interview report in order to make interventions and reinforce practices that further the goals and objectives. Specific questions asked are featured in the data summary of this report.

[6] Research Outcomes. The IGERT program coordinator collected research outcomes from the faculty and trainees each year of the program including the following metrics: conference presentations, published abstracts, manuscripts submitted and published, travel awards submitted and gained, and grants submitted and awarded.

[7] Educational Outcomes. The IGERT program coordinator tracked each student's GPA, years taken to candidacy, years to complete their graduate degree and other educational outcomes.

[8] Trainee Achievements. The IGERT program coordinator tracked each student's achievements including but not limited to conference presentations and published papers.

[9] Outreach Activities. The IGERT program coordinator summarized outreach activities conducted by the students.

[10] Partnerships/Collaborations. The IGERT program coordinator has listed partnerships including but not limited to funding arrangement, activities, and personnel exchange.

[11] Longitudinal Alumni Outcomes. Sage will reach out to the program alumni during the project period to document their current career or education status, influence of research experience, mentor advice, and satisfaction of overall education programming. The alumni will also be asked the outcomes of their research including but not limited to presentations, publications, and conference attendance.

Results will be summarized by Sage and provided to the IGERT Executive Committee. The IGERT project team and evaluator will meet each May to review the formative results in order to make interventions and reinforce practices that further goals and objectives.

IMPACT ON STUDENTS

The evaluator interviewed 21 IGERT trainees and affiliates from the three participating universities. The breakdown of the number of trainees and affiliates from each home university is listed below. There were three IGERT alumni that did not return e-mails and/or phone messages. The evaluator and coordinators will continue their efforts to contact them for the 2016 evaluation report.

	IGERT Trainees Total / Interviewed	IGERT Affiliate Total / Interviewed	Number of Students Interviewed
USD	7 / 6	4 / 4	10
SDSU	5 / 4	0 / 0	4
SDSM&T	6 / 5	1 / 1	6

The interviews were analyzed for themes and the number of respondents (students) who identified the theme is listed in parenthesis. Quotes that represented student feedback are listed under some themes and are *italicized*. Some students listed two or more themes under each questions so the sum of respondents may be greater than the number of students interviewed.

■ What did you like best about the program, and what would you describe as the strengths of the IGERT program?

Overall, the students listed several strengths of the IGERT program and reflected how those strengths positively impacted their academic careers. Below is a summary of their responses ordered from most to least popular response.

Interdisciplinary courses via the Access Grid (10 respondents)

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.

Outreach activities (9 respondents)

"Outreach programs are focused at venues in the community program including K-12 education and Native American audiences."

"I believe outreach should be included in every project. For me, outreach is vital. We received the benefits of the grant; we should pay society back through outreach."

Campus rotation (7 respondents)

"I had a fun time there. I planned everything in advance. I focused on applied research as I did not have to do much course work. I got a lot done while at the SDSM&T lab."

USD, SDSU, and SDSM&T Cohort (7 respondent)

"I like the interaction with students from other campuses. For example, an IGERT trainee from SDSU came to our campus, SDSM&T, for a semester. I was able to collaborate my project with him."

Stipend and research funding (6 respondent)

"The IGERT stipend allowed me to pursue my Ph.D. and career path."

Conferences (5 respondents)

"Conferences keep you up to date and provide ideas of what steps you can do next."

Interdisciplinary research projects (4 respondent)

"I had the freedom to choose a project that aligned with my research project and dissertation. ...and that was an interest to me."

Mentoring and Advising (2 respondent)

"Also liked that at SDSU, in the beginning, there was a special meeting for IGERT students to evaluate our progress. Dr. Galipeau led that effort and it was helpful to students."

"Faculty will collaborate and are very enthusiastic and have a passion for this program."

Symposiums (2 respondent)

■ **How does an IGERT educational experience differ from that received in a traditional single disciplinary program?**

During the interviews, the students expressed gratitude for being able to grow their skills outside classrooms and laboratory within their discipline via the IGERT program. All of the students did not hesitate to note the differences listed below.

Interdisciplinary classes via Access Grid. (15 respondents)

"The course work gave me a more broad learning experience than a traditional disciplinary tract."

Interdisciplinary research. (9 respondents)

"The IGERT program requires classes and research outside of your discipline resulting in a well-rounded student."

"Being able to incorporate engineering concepts into my research project."

Outreach. (7 respondents)

"The outreach component was a big aspect of the program. It made a major difference in my experience."

USD, SDSU, and SDSM&T Cohort. (5 respondents)

"The interaction with other program students and developing connections with faculty and students. I also appreciate the social aspect and networking."

"I was able to spend a lot of time with people outside my discipline which resulted in more collaborative opportunities."

Campus rotation. (4 respondents)

"I did my campus rotation with Dr. Koodali at USD. I liked the challenges. Dr. Koodali is one of my role models. He is helpful and motivated me to work very hard for him. He is a very productive guy. I liked his style of research and I will probably follow his way of how to conduct my research."

"I appreciated a second advisor from another university and in another discipline. I really appreciated my USD mentor - Dr. Hoefelmeyer. He was a good coach. I spent a whole summer in his lab. I was there 4 days a week. I learned a lot and was satisfied with results. It was a very worthwhile experience."

Stipends. (2 respondents)

"Stipends are definitely more than what traditional graduate students are paid. It wasn't really a determining factor for me, but was definitely a pro. It was more of a decision of if I wanted to leave this University with a Masters or PHD."

■ **What is the value of being in a cohort with peers from three South Dakota universities?**

Network/Friendships. (8 respondents)

"I have good friends for life through IGERT. Will stay in touch through social network and professional networks. That is a benefit."

"Sharing the similarity of going through an interdisciplinary process. The disciplines – chemistry, nanoscience, electrical engineering - broadens the thought process and vocabulary. The sense of community was strengthened by monthly meetings. It was nice to share the experience with others."

"Being in the IGERT group feels good, like a fraternity. Not everyone gets in. You feel special."

"The program broadens your world. Otherwise, I would stay in my department. We are able to interact with graduate students that we would never have the opportunity if we were in a traditional disciplinary program. We will be able to network for the future. The other students are very dedicated to their field."

Collaboration – Research. (7 respondents)

"The biggest value would be the collaboration aspect. Getting trapped in your own little bubble is common in research, and getting a broader perspective from others is good. Our research is all renewable focused, but the emphasis from each discipline is very different."

"By joining the IGERT regular meetings and the rotation, I had many chances to learn what other research groups were doing. I was doing projects related to solar cell fabrication at one time. By knowing what nano materials other groups were making, I was able to get some ideas about how to utilize those materials in my projects. If the materials did not meet all the requirements, I could propose it, which created another research topic. I also learned that there are a few ways to create clean energy."

"Scientists and engineers think differently and approach problems and projects differently. These different approaches help the team."

Leveraging the strengths of South Dakota's regental system. (6 respondents)

"The South Dakota universities generally do not replicate programs. For example USD specializes in material chemistry, SDSM&T in nanoengineering, metallurgical engineering, and chemical engineering. SDSU in electrical engineering. This program allowed students to benefit from the faculty with expertise spread across the state."

"Makes you feel like you're part of a community of researchers in the State; if not for IGERT, we might not know what others are doing in the State. Since we're smaller programs, it's nice to be part of a consortium of institutions."

Collaboration – Outreach. (3 respondents)

"Access Grid allows us to get to know each other which makes the collaborative research efforts easier when we do work together."

■ **How did the governance structure help and/or hinder the program?**

The IGERT student-led governance committee met on a monthly basis. Agendas included external speakers, outreach coordination, symposium coordination, and other overall coordination activities. The meetings were facilitated on the Access Grid and provided the students an opportunity to get to know and interact with each other. The students provided the following feedback regarding the governance structure:

Yes, the governance structure was helpful. (19 respondents)

"The governance meetings were monthly reminders of who we were."

"Within the last year, they've done a good job with planning events and getting speakers to come. Our last meeting in Sioux Falls was well organized, and the speakers were interesting and relevant. They weren't all scientists – solar panel installers, for example – so was nice to see the other perspective."

"They ensured that the students got enough support during campus rotation, such as helping students to rent an apartment for a short period."

"We dictate what we want to do. Dr. Berry coaches the group. Laura helps us facilitate outreach programs. The outreach programs are coordinated at a governance level. We do all of the work. The integrated research completed is beneficial for career and professional development. In October, the students organized a symposium and flew in a number of speakers (e.g., NREL)."

The governance structure was neither helpful nor a hindrance. (2 respondents)

"The student governance program is just so small that I wonder if it is necessary. We are all so busy. It is hard to communicate with everyone. We are all so busy and have a lot of responsibilities. For presidents, it took a lot of time away from research."

The following suggestions for improvement in the governance system were provided by the students:

- Reinforce participation and attendance. If there is no consequence for not participating, students view participation as optional, leaving the burden of coordinating activities to the remaining students.
- Ensure everyone can hear each other on the Access Grid.
- Hold the meetings on a monthly basis allowed a balance between research and attending, preparing for, and following up on meetings.
- Rotate positions with all students so they know what it is like to lead the group.

■ **Tell me about the outreach experience you facilitated and/or participated in. Was it a positive experience? If yes, how so? If not, how can it be improved?**

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. The outreach experiences below were listed by the students during the interviews along with their perceptions of how the experience shaped their skill sets and influenced their outlook.

Nebraska Indian Community College – Workshops (4 respondents)

During a two day workshops, the IGERT students would demonstrate to NICC and K-12 students' science concepts, particularly on renewable energy. For example they taught them how to use a solar cell to generate energy. The target audience appreciated it as they could further develop possibilities of generating energy locally. The IGERT students' goal was to have the students continue to take science classes.

Nebraska Indian Community College - Courses (4 respondents)

The IGERT students developed two chemistry courses for NICC students: Chemistry 099 and Chemistry 110. The students developed the syllabus, taught the course, developed and facilitated laboratories, and graded course and lab work. An additional challenge was the classes were simultaneously broadcasted to satellite sites. The lab supplies would be shipped prior to class and the instructors would coach the students over the satellite connection. The courses were coordinated with the assessment program.

"The NICC experience validated that I wanted to go into academia."

Hank Miller, NICC Natural Resource Instructor / Math & Science Division Head, provided the evaluator the following feedback:

The students were a wonderful group of students. By developing the two chemistry classes, we were able to get our chemistry program off the ground. *It was a game changer for us.* IGERT students gave us the jump start we needed. We simply did not have enough budget for a science program. Additionally, we cannot recruit instructors or teaching assistants in rural Nebraska.

The program they developed is now being facilitated by a chemistry grant through University of Nebraska - Lincoln. A graduate student/teaching assistant is now teaching the course and facilitating the labs.

The NICC chemistry course development and execution was good experience for the IGERT students. They have experience in a) underserved areas; and b) teaching. Overall, their efforts were great and very appreciated.

If we were doing this again, the grant should include monies to:

- a) Try to incorporate cultural relevancy.
- b) Being physically present at all three campuses. Perhaps rotating the instructor role at one campus and having the other two others be TAs at the other two campuses.

Our students are bright, dedicated students. However, a lot of base work needs to be addressed. Many of our students do not understand what it takes academically to succeed.

Children's Museums (15 participants)

- **Sioux Falls Washington Pavilion.** (10 participants)
The IGERT students presented posters on renewable energy. The target audience was 8th grade and younger.
- **Sioux City Children's Museum.** (5 participants)
The IGERT students demonstrated science projects to a target audience of children to increase interest in science.

SD GEARUP Summer Honors Program. (4 participants)

The IGERT students organized and facilitated a 2-day workshop for the SD GEARUP Summer Honors Program hosted at SDSM&T. The six-week residential program is offered to low-income students who show a capacity for higher achievement, with focus on middle school students. The IGERT students explained complex science and engineering concepts to these children in a way they could understand and become interested. Their message was a) finish high school; b) go to college, c) major in STEM discipline; and d) see what scientists do on a day-to-day basis. They purchased microscopes to look at small things such as ant hairs and then let the students keep the microscopes. They showed the youth a typical day in a scientist's life.

Science and/or Engineering Focused Workshops or Speaking Engagements. (5 respondents)

- **Sinte Gleska University.** "I helped with a workshop. The target audience was non-chemistry majors. The professors are trying to get them into the lab and increase their interest. That was good for me to see."
- **Women in Science Conference.** "I was a speaker at the Women in Science Conference in Pierre and encouraged young women to consider science."
- **Whittier Middle School in Sioux Falls.** "My favorite experience was working with 6th graders at Whittier Middle School. I feel it was a very positive experience for both me and the students. It was fun for me to teach the children about what we do as scientists and even help them better understand the word "nano." I feel they also had a fun time with learning and getting to do a hands on experiment, which they synthesized their own gold nanoparticles."
- **Vermillion Public Library.**

- **Kindergarten Workshop.** *"I did my outreach by teaching kindergarteners about the atomic-level. It was a positive experience. For many kids it was the first time that they realized that there are somethings that are not observable but do exist. I hope that would inspire them and make them more enthusiastic about science."*

Youth Engineering Adventure. (2 respondents)

Youth Engineering Adventure is a one week camp hosted by SDSU engineering program during the summers. The IGERT students hosted three sessions of electronics to high school students. They assembled a little electronic bug kit that can drive by sensing lights.

SDSU Elementary Student Tour. (1 respondent).

Elementary students toured SDSU and the IGERT student was in charge of showing the clean room. The IGERT student gave them pennies that had been coated with aluminum on one side to illustrate what a thin film can be/look like.

College Courses (2 respondents)

"I independently taught a summer chemistry class at Mt. Marty College including writing a syllabus and developing laboratories. It was an intense month. This month was very helpful for me. Right now, I put this on my vitae. This experience held much more responsibility than a teaching assistant (TA). Most Ph.D. students have been just TAs. I have not talked to any other Ph.D. students who had that much responsibility."

"I now teach adjunct for Dordt College. I have 35 students – chemistry for engineers and running my own lab. This experience has been a good for me."

Additional comments:

"We have been invited to Nebraska and South Dakota venues for other outreach projects."

"Thanks to Laura Kuschel for helping us with outreach projects!"

"Dr. Sykes has been very helpful in facilitating networks."

*"I believe outreach activities are paying forward for those who have influenced me along my career. When I was in 6th grade, (university) students judged our science fair. They also facilitated a variety of experiments. One was a very large volcano of baking soda reacting with vinegar. That 6th grade science fair and the Stanford students made an impact on me. **I knew then that I wanted to go into a STEM field. I hope I can influence a young person to make the same decision.**"*

Suggestions for outreach projects:

- Allow coordinator to help facilitate outreach activity logistics.
- Outreach projects which involve teaching K – 16 audience is valuable to the graduate students.
- Other activities that do not include teaching and involve a lot of time are a drain to the students and take away time from research. Ultimately those activities did not have an impact on skills, etc.
- Dr. Berry should make it clear to graduate advisors that outreach activities and programs are important. Not all advisors see this as important and do not want to take the time.
- Workshops should be longer than 2 days at a campus (like NICC). The workshops should be one week at each campus.

■ **Has the mentoring and advising been helpful? If yes, how so? If no, why not?**

Unlike traditional single disciplinary graduate programs, IGERT students have two faculty advisors. Their primary advisor is at their home institution and they have another advisor at the campus where they chose to do their rotation. The students noted that the advisors allowed the students to work independently and

provided coaching and assistance when asked. The direction was important earlier in their academic career and became less frequent once the students became more mature in their academic career. The following are the students' viewpoints of their advisors.

Yes, my advisors were very helpful. (21 respondents – 100%)

"They are very helpful and provide advice on my research project as well as future career advice."

"Dr. May and Dr. Berry have been incredibly helpful. I owe them a lot."

"Definitely... the times I struggled the most was when I was early on without an expert advisor and I would spin my wheels a bit. I really appreciate Dr. Galipeau; he was always at the initial IGERT meetings."

"I very much appreciate that I got a great deal of help from my mentors. I learned how to conduct research, how to present my lab results concisely and clearly, how to retrieve the knowledge that I needed, how to write papers and a dissertation. I also learned a lot through this program. Without the help that I received, I would not able to be what I am now."

"My mentor encourages IGERT activities. He is a collaborator."

"Dr. Koodali is a very good advisor. He is very, very involved. He sets the expectations high for himself and his students. Serious about the research. Goes above and beyond. A+++ Personally – he is helping me look for opportunities."

"Dr. Berry and Dr. Kooldali provided opportunities for us. They put a lot of effort into IGERT to make it a good experience. It showed."

"Dr. Berry is very good. If you have questions, she has a very open door."

"Dr. Sykes and Dr. Berry are very approachable. It is sometimes difficult to get an appointment with them. They are very passionate and dedicated the program. They are not babysitters. We are adults. This is what we need - a coaching role."

Please note specific faculty are noted favorably in the quotes above. However, all faculty had positive reviews.

■ **Have any of you had the opportunity, or will you have the opportunity, to present your research in the future? Be published?**

Publications and presentations from the IGERT faculty and students are captured in annual reports. Each student has had the opportunity to be published and present. Below is a summary of the students' responses.

Published a paper. (16 respondents)

Presented a paper at a national conference. (12 respondent)

Currently working on one or more papers for publication. (5 respondents)

Not yet. (1 respondent)

A patent was awarded for a product of research. (1 respondent).

"The IGERT research provided the framework for a NSF SBIR Phase 1 grant project. I was awarded the grant and took a year off to complete the SBIR Phase 1 grant project."

■ **What aspects of the program did you not like?**

Overall, the students believe the program was well-designed and only had minor suggestions. The most significant finding that the IGERT team could influence was matching students with cross-campus advisors. In most cases, the match was optimal. In three cases, the students were not satisfied with their match; however, have managed to gain value from the campus rotation.

I would not change anything. (8 respondents)

I would suggest changing... (5 respondents)

- Monthly governance meeting. Scheduling meetings with 3 campuses in 2 time zones was difficult. The meetings were sometimes tedious. (2 respondents)
- Make governance meetings a requirement.
- The grant favored U.S. citizens. It should include all students in order to attract the best people.
- Campus rotation. There were limited opportunities to do campus rotation; and it was difficult to find an advisor whose research and laboratory matched my research focus.

Rotation was not successful (3 respondents)

"I feel like my summer was robbed. I did not accomplish my goals during my rotation."

"I wish it would have been aligned with the research of my group. Nano versus organic (his interest) chemistry. ...so ended up with 2 projects for my dissertation. Not horrible but not optimal."

"It was difficult to pick a collaborative project and an advisor and relate to them."

■ **How did this experience influence your career choice?**

Evaluators typically ask undergraduate students who have had the privilege of participating in summer or academic year research programs if their experience influenced their choice to pursue graduate education and eventually a research career. By the time individuals have completed their bachelor and master's degrees and are earning their Ph.D. degree, many have mapped out a career path. Although some IGERT students are on the career path they originally envisioned when entering the program, other students have been influenced to alter their plan based on their IGERT experience. In some cases, IGERT validated their career choices.

My career plans have been influenced by the IGERT program. (13 respondents)

"When I was completing my MS degree, I was aiming toward a career in industry. While I was applying for job, my professor, Dr. Kellar, convinced me to do pursue my Ph.D. with the aid of the IGERT collaborative. It got me into graduate school."

"Yes – definitely. Dr. Berry does a great job helping students. I have now decided to go into academia. I attained my Ph.D. in materials chemistry from USD. While in the IGERT program, I did a campus rotation. IGERT played a key role in getting his post-doc position at SDSM&T."

*"I originally wanted to go into academia to do research, but now more focused on entering industry or a government lab. I might take a swing at batteries for that reason. **I probably wouldn't have done the PHD without IGERT.**"*

"(After becoming a faculty member) I would like to pay forward the benefits of the IGERT program by contributing to a similar program."

"I believe the IGERT experience helped me get my current position as a post-doc at University of Chicago. I am sure it will help me get a faculty position."

"I am interested in continued research in renewable energy."

"I feel this experience has influenced my career choice by giving me the confidence to work with other scientific backgrounds. This is most apparent in my current position. I am currently working as a post-doctoral researcher at Uppsala University in Sweden for a solid state electronics division even though my background is in material's chemistry."

My career plans have been validated by the IGERT program. (3 respondents)

"I would like to pursue a career in academics. The outreach experiences has been very helpful and validated my choice."

I am still unsure of my career plans. (3 respondents)

"The IGERT rotation will give me opportunity to explore both paths – teaching and laboratory."

My career plans have not changed. (1 respondents)

■ **If you could pick the one, most important thing that you learned from this experience that you will carry with you to your career, what would it be?**

The South Dakota IGERT program was designed to not only include interdisciplinary courses and research but also campus rotations and outreach experiences. The additional opportunities provided rich experiences that prompted the responses below.

Collaboration with interdisciplinary partners. (7 respondents)

"I believe the key benefit I have received is having not only depth (in my field) but also enough breadth to collaborate with others. Collaboration with others is a key to success."

Community outreach (3 respondents)

"Learning how to communicate science with the general public, and small children – you don't get exposed to that if you're just doing a traditional program."

Network opportunities with professionals in my and related fields. (2 respondents)

Project management/Time management (2 respondents)

"I think organizing the symposium was valuable including administrative duties, determining content, planning logistics, and leading the effort. I learned time management skills."

Communication skills. (2 respondents)

"The outreach program forces you to explain complex chemistry concepts in basic language. Going back to the basics was challenging. Communicating chemistry in simple terms is key to business and marketing people."

Research experience. (2 respondent)

Keeping the end in mind. (1 respondent)

"It's always important to look at the big picture; it's easy to get caught up and focused on small details of a research project, but as an engineer we have an end goal --- we're trying to improve, build, make, etc --- it's important to step back and re-approach to achieve the end goal. It is different than basic science research; we're not doing this just to do it or learn more... we have an end game in mind."

Interdisciplinary courses. (1 respondent)

"In my academic career, I want to design courses that are multi-disciplinary."

Independent thinking. (1 respondent)

Personal confidence. (1 respondent)

Keep studying – pursue your Master's and Ph.D degrees. (1 respondent)

■ **Would you make any changes to the IGERT program to improve the experience next year for the students?**

One of two students stated they had no suggested improvements. The remaining students had suggestions that can be summarized in five themes.

Industry and National Laboratory Internships. (9 respondents)

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. Seven students 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.

Foreign Students. (3 respondents)

The IGERT program was designed for U.S. citizens. The affiliates who participated along with a few of their U.S. citizen peers expressed they wished future grants would provide stipends for foreign students in order to attract best candidates, regardless of citizenship.

Campus Rotation Expansion. (3 respondents)

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.

Campus Rotation Planning. (3 respondents)

The students who did not have a good rotation noted one or more barriers including: a) host advisor did not interact with the student; b) not enough time at host campus; and c) logistics (passwords, keys, etc.) were not planned or ready prior to student arrival.

Annual Review. (1 respondent)

When the students first joined IGERT they created a proposal which listed goals. A student 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.

Additional suggestions included:

- Keeping IGERT alumni up-to-date, particularly if they are still on campus.
- Including health care coverage along with stipend.
- Including more students from SDSU and SDSM&T.

■ **Would you recommend the IGERT or similar program to other potential trainees?**

Although the National Science Foundation is phasing out the IGERT program, programmatic learnings will be incorporated in graduate programs in the South Dakota regental system. One hundred percent (100%) of the students state they would recommend the IGERT or similarly designed program to other potential trainees.

■ **What are key success factors to a successful campus rotation?**

During the interviews, the external evaluator asked those students who indicated they had a positive and productive campus rotation what the key success factors were to a successful campus rotation. The following reflect the suggestions they provided:

- Allow time to collect enough data during the campus rotation. Those who expressed satisfaction with the rotation spent the entire summer or semester at their host campus.
- Get to know the students and the faculty from the host institution via the Access Grid, conferences, e-mail, phone calls, etc. prior to the rotation.
- Plan the experimental designs in advance and ensure everything is in place (materials, supplies, equipment) prior to arriving.
- Arrange passwords, keys, and other logistical items as much as feasibly possible prior to rotation.
- The host advisors carved out time during first week to teach instrumentation and ensure factors are in place for success.
- Communication was key. If there was not a good communication between groups then the rotation seemed to hinder, but if there was good communication then the rotation thrived.

Student ID Code	How many years did it take you to get your degree?	What was the contribution of the campus rotation research to your dissertation?	Qualitative value of campus rotation research to dissertation
A	5 – M.S./Ph.D. (USD)	I wrote a chapter in my dissertation from the rotation research.	10%
B	4.5 – M.S./Ph.D. (USD)	I published two papers during my campus rotation.	40%
C	3 – M.S. (SDSU) 2.5 – Ph.D. (SDSU)	None of the research or work from my campus rotation was directly incorporated into my dissertation. However, a lot of the skills and general knowledge learned during the rotation, specifically regarding nanoparticle stability in solution, was a major component of my dissertation work.	25%
D	1.8 – M.S. & 4.5 – Ph.D. (SDSM&T)	Most of the important analytical and materials characterizations for my dissertation were conducted during campus rotation and continued visits afterwards.	50%
E	5.5 – M.S./Ph.D. (USD)	The research and knowledge i picked up during my campus rotation.	50%
F	~3 – MS (Kansas State University) 5 – Ph. D (USD)	The campus rotation contributed one chapter to my dissertation.	11%
G	2 – MS (Idaho State University) 4.5 – Ph.D. (USD)	The campus rotation provided me with valuable training in photovoltaic device physics, and provided a peer-reviewed publication and an award-winning conference proceedings paper that together comprised a chapter of my dissertation. It also provided me with experience that will allow me to collaborate with the engineering faculty at Iowa State.	25%
H	5.5 – M.S./Ph.D. (USD)	The contribution of the campus rotation research to my dissertation was not extensively included. The majority of contribution from my rotation to my dissertation was of quality discussions about the nanomaterial. (<i>See note below</i>)	10 – 15%
I	2 – M.S. (SDSU) 5 – Ph.D. (SDSU)	My dissertation project was an interdisciplinary project which required both engineering and chemistry background. During campus rotation, my advisor at the rotation site gave me a lot of suggestion from the chemistry point of view, which greatly enriched the investigation of creating the desire silicon surface structure for engineering application.	30%

Note from Student "I": *However, I would like to make it known that the rotation was extremely valuable for my current position. I am a post-doc research in a solid state electronics department. The valuable insight that I learned from working with engineers during my campus rotation has helped me tremendously at this position.*

Our department of Solid State Electronics at Uppsala University is comprised mostly of engineers, thus it was tremendously beneficial to work with them during my studies."

In summary, students were very appreciative of the experience. All recognized the important role Dr. Mary Berry, IGERT Principal Investigator, had in the program. When concluding the interviews the evaluator asked if the students had anything further to add, several noted **"Tell Dr. Berry – thank you!"**

IMPACT ON FACULTY

The evaluator interviewed 11 IGERT faculty from the three participating universities: six from USD, two from SDSU, and three from SDSM&T. The interviews were analyzed for themes and the number of respondents (faculty) who identified the theme is listed in parenthesis. Quotes that represented faculty feedback are listed under some themes and are *italicized*. At times faculty listed two or more themes under each questions so the sum of respondents may be greater than the number of faculty interviewed.

■ In general, what was the most positive part of your involvement in the IGERT program?

All of the faculty interviewed fell into one of three categories: a) their Ph.D. advisee was an IGERT student; b) they advised an IGERT student from another university while student rotated through their laboratory; or c) both (a) and (b). All faculty were very positive regarding the project and provided a variety of answers.

Rotating students to at least one other campus. (7 respondents)

"The rotation at campuses outside their home institutions has a positive impact on their research and studies. For example, Student E was able to do his/her post-doctoral work at SDSMT as a direct result of his/her rotation with Dr. Smith."

"IGERT smashes the model of a traditional disciplinary program and forces you to work outside your field and comfort zone. Scientists and engineers working together on a mutual project is beneficial to both the student and faculty."

"The rotations force the student to move away from their home institution research. That is what IGERT is all about. One student got lost but another student thrived. You will have variable outcomes. The rotation component is very unique to IGERT. "

"In PANS, there were virtual meetings but with IGERT the student actually came to campus. Both PANS and IGERT had far reaching consequences."

"My students went on a rotation to SDSU and collaborated with the electrical engineering department. It resulted in a publication. Without the IGERT, the student would not have had that opportunity."

Expanding students' knowledge beyond their discipline. (7 respondents)

"I saw dramatic improvement in the students' professionalism, vocation, ambition, and early leadership. They did a really good job organizing symposium at MRS. Good job with rotations. They take outreach component very seriously."

"Team of scientists/engineers –coming together to solve global problems. The chemists come up or find with materials. They students grow and learn with campus rotations."

"The most positive part of the USD IGERT program was the opportunity to get interdisciplinary exposure to the electrical engineering program at SDSU and nanomaterials science and nanomaterials engineering program at SDSMT."

"Students learn that problems are quite complex and an interdisciplinary approach is required to solve complex problems."

"IGERT has increased and improved the students' communication skills. For example, the governance program forces them to organize meetings and projects, organizing and executing outreach projects, and organizing a symposium at a conference. This has prepared them to work in academia or industry where similar communication issues are present. We need to communicate so that everyone can understand."

Collaborating on research projects (5 respondents)

"The program rotation did force collaboration, and fostered it. It made us stop and think about how to integrate and collaborate and get the most out of the student as they rotate through. Creating publications together was also a good experience. We have several papers in progress, and still participate in helping those students with their dissertation and publications."

"Value/advantage is that it provides a relatively stable level of student support so we can do both research and education, which is part of our mission. Concurrently, IGERT provides the over-riding structure for the students where they their own seminars, outreach, etc."

"For comparison, NSF grants are much more research focused. IGERT balances that as it gets the students to think about more than just research – outreach, teaching, seminar, forum for collaboration. This level of collaboration is not commonly afforded."

Advising and mentoring students. (5 respondents)

"The students essentially have two faculty mentors – one at their home institution and one at another institution. The collaboration lasts longer than the student's rotation as the research takes months/years to complete. Two advisors is important"

"Hosting students from other universities in my lab."

Developing a student community. (2 respondents)

"They were a part of larger communities within and outside South Dakota. They were involved with the ACS and MRS programs. As students, they organized symposiums at national conferences."

"Student governance was very useful. Initially, we believed they would be a representative group to provide feedback to the faculty or be liaisons between the faculty and students. However, they have played a larger role with emphasis on projects. Really nice."

Teaching classes on the Access Grid to interdisciplinary student audience. (1 respondent)

Establishing a pool of funding for students. (1 respondent)

■ **What effect has the IGERT program had on your research?**

All faculty interviewed indicated the IGERT program had a positive effect on their research. The feedback was themed into three areas: a) expansion of research topics; b) graduate student funding; and c) student rotations through partner SD IGERT universities.

IGERT expanded our research into new areas that would not otherwise be possible. (6 respondents)

"Allowed us to expand our research focus; each campus received four students. Allows us to explore areas that we're not ready to write a full proposal on yet; allows us to generate preliminary data in new areas of research."

"Because of the PANS and IGERT collaborations, our research efforts have serendipitously led to other projects. They led to the state center (of research collaborators)."

"Increased/pushed the quality of the research project due to the interdisciplinary coursework and networking."

"Additional grant projects As a result, three additional grant projects were awarded to USD and/or collaborative partners: 2 NASA grants and a DOE solar conversion grant."

"Based on the work completed by the IGERT funding, they were able to apply and receive funding from the National Science Foundation (NSF). The research is now continuing due to the new NSF grant."

IGERT allows funding for graduate students to conduct research. (4 respondents)

"I would just say it enhances the research through the participation of the graduate students, interdisciplinary focus, and collaboration with other faculty from other campuses."

Ph.D. candidates outside my university and my field work rotate through my lab. (2 respondents)

"Served as a rotating mentor, and have done some collaborative papers out of the connections – not necessarily the IGERT work – but has definitely had a positive impact."

"The rotations work really well. Early on, they had a few bumps with rotations but worked that out. Now they are making sure they have a project with advisors. Both advisors work with students to map out research project so everyone involved is on the same page. All of my students have had an excellent experience."

■ **What is the added recruitment value of the IGERT project?**

Of the three South Dakota IGERT institutions only USD formally used the IGERT program in their recruiting material for graduate students, where it was included in their literature about the chemistry program. The SD IGERT web page also helped to funnel prospective students into USD. As a faculty member noted, *"People from all over the world can look at our program and imagine themselves here."* They believed the IGERT program increased their prestige in the eyes of prospective students.

At all SD IGERT universities recruiting was primarily conducted by the faculty to students who they believed had the potential to succeed in this program. Students applied to the program through a formal application process. The engineering programs, in particular, have a more difficult time recruiting Ph.D. candidates due to a) the lure of industry salaries; and b) industry recruits primarily undergraduate or master's level engineers.

The IGERT program helped recruit a better caliber of students. (5 respondents)

"It is challenging to recruit U.S. citizen graduate students into engineering programs."

"Immense. At the 2015 ACS conference, I visited with the student. I indicated the a) interdisciplinary opportunities; 2) stipend; and 3) outreach. IGERT is VERY effective in recruiting."

"The IGERT program was definitely a draw to Ph.D. candidates to USD. The interdisciplinary course work and research as well as the collaboration between South Dakota institutions was an attractive option versus other programs that did not have this opportunity."

IGERT develops skillsets for securing jobs and building careers. (3 respondents)

"Very effective interdisciplinary training. They have the skillsets for the industry in multidisciplinary team. This experience is very critical to finding jobs."

"The IGERT student resumes are set apart from others in a traditional disciplinary track. For example, the students took the lead role of teaching a course in chemistry at Mt. Marty (international student). A team of IGERT cohorts developed a chemistry course for the Nebraska Indian Community College. This outreach program is not traditionally afforded to traditional students. They prepared lectures, graded homework and tests, prepared and facilitated labs. They understood the preparation involved in being an instructor. "

"After this program, they could apply for national labs, academia, and industry positions."

The IGERT salary is competitive. (3 respondents)

"Salary levels are generally higher than what we can typically offer; it gives us the ability to attract the US citizen type students who traditionally are more attracted to high industry salaries. Makes us more competitive."

A comprehensive recruiting plan for all universities would have aided recruitment efforts. (1 respondent)

A recruiting challenge is finding US citizen candidates versus international candidates. (1 respondents)

■ **What are the characteristics of students being recruited into IGERT programs, and how do they differ from traditional graduate students?**

Most faculty indicated they could not initially distinguish differences in IGERT students versus traditional graduate students. However, once the students were one or more years in the program, the skillsets differences became more apparent.

After the first year of being in a PhD program, students can apply to be in IGERT. Criteria included:

- Academic preparation
- Demonstration during the first year
- Research productivity
- Proposed research
- Competency to be productive to do research
- Supporting letter from faculty
- Primary research; secondary research up to a semester of campus rotation which will be a chapter of their dissertation
- Be very effective in communities through outreach and teaching. In other words, they must have good social skills.

"When reviewing applications we want scholastic ability, demonstration of diligence to complete additional activities required in the program. We have the candidates complete one year of their regular program before they apply for the IGERT program."

The skillsets are transformative over the course of their participation in the program. (5 respondents)

"I did not see a big difference initially but did as they progressed."

"Students also led seminars and programs, so they get some leadership training that they otherwise wouldn't get."

"I really do think the IGERT students have a leg up into the research world due to their interdisciplinary training, communication, and leadership. They are light years ahead due to a) whole group of researchers; b) all investigator meetings; c) not isolated; d) rotations; and e) outreach."

IGERT students embrace collaboration. (2 respondents)

"IGERT students tend to be much like the faculty participants. Willing to work across disciplines and willing to collaborate."

"IGERT recruits are certainly more willing to do the outreach components, so they are probably more extroverted, have broader perspective in terms of doing more than just the research. More willing to interact and be more collegial."

■ **How does participation in IGERT impact faculty teaching, research, mentoring, networking, and productivity?**

Teaching (6 respondents)

"Many of the IGERT and PANS faculty overlap so they are familiar with the Access Grid system. I taught (4) three credit classes – three times a week."

"The Access Grid has been the key to the success. Tremendously helpful to work with other university professors at other universities."

"The IGERT program has significantly helped me to integrate research and research concepts into teaching. I have integrated organic chemistry research into my classes. The coursework is more challenging but I have received positive feedback from students."

Research. (3 respondents)

"Real collaboration – it's not just virtual e-mail connections... we really got to know one another. The IGERT students come, the faculty come, we talk regularly, and we mentor them... very involved. We work on this collaborative project where we queue up different aspects of the research... pure collaboration."

Mentoring. (2 respondents)

"The faculty have a joint responsibility to mentor/advise a student on a collaborative project. So there is a fair amount of coordination. The collaborative faculty's teaching content and method impacts the other faculty through the way they train the graduate students."

"It is also good to have other faculty co-mentor your student. It allows you to do more. End result is more productivity for everyone."

Networking (1 respondent)

"The faculty meet face-to-face once a year in Chamberlain coinciding with the EPSOR meeting. At that meeting, the students look for collaborative opportunities with faculty outside their home institution."

Productivity. (1 respondent)

"The IGERT program increases research productivity resulting in a lot of publications. Most of my publications were impacted one way or the other from the IGERT program."

■ **What do you value the most about being an IGERT faculty/research mentor?**

Student impact. (5 respondents)

"It's nice to see when they go on and are successful and they come out with a nice job."

Collaboration with interdisciplinary faculty across the state. (5 respondents)

"I LOVE to collaborate. The biggest draw to IGERT. Part of that is the people. If you get know the faculty and students and you like working with them, the research comes naturally."

Campus rotations. (3 respondents)

"I was skeptical that campus rotations would not work but it didn't have that effect. The students got some things accomplished. A surprising result. The traditional response would be to not pull them away from their research at their home university. They were actually more productive at campus rotations."

"IGERT allowed us to have inter-campus exchanges/rotations, which was a huge benefit for both faculty and students. A big plus for us to have that built into our IGERT program. We now have a strong program of inter-institution collaborations. I would advocate to keep this a key piece of the program. Certainly within SD – is needed here because of our State size."

"My student's rotation is a major piece of his dissertation."

■ **What do you value the least about being an IGERT faculty/research mentor?**

Of the 11 faculty interviewed, only three replied to this question. Two of the three believed the campus rotation time may be too short. The remaining eight faculty members said there was nothing about the program they valued least.

"Need to be cautious about having too many students attending a graduate level class on the Access Grid."

"I was a rotation mentor for two students; and one that was here for a little while. I thought a rotation was supposed to be a full term (3 months); seemed like that got squeezed down a bit. Seemed to be demands from their own group and school to put pressure on them to make it 2 months instead of 3 months, which made it kind of hard. Three months is a time period we're accustomed to dealing with (like a summer) but it's still quick. Much shorter than that is tricky to get things set up in time and generate anything reliable/useful."

"The level of effort to set someone up to only have a short amount of time to work with them... but we can't expect students to be away from their home institution for much longer on a rotation schedule. The intent is to get them a taste, which I think we do, but it's short. They maybe take something from their mentor, from a host mentor, and then put that together to how they want to run a lab in the future... that's valuable."

■ **If you were to design the program again, what change(s) would you make to improve the program?**

Research planning. (4 respondents)

"Have rotations mapped out. Both professors invested in research should lay out a written research plan with the student. The program had a couple of bumps early on. The other professor integrates new skillsets in that project. I would recommend incorporating that requirement upfront – make sure that was programmatic."

"Meeting every quarter with PI and Co-PIs on Access Grid. E-mail did not do the trick. Exchange ideas and best practices. Best way to do this is face-to-face or virtual meetings."

"Place the bar higher by asking for more involvement. For example, require more work produced, more publications, more interdisciplinary research, etc."

Industrial and National Lab internships. (3 respondents)

"Do not include internships. The logistics of internships are difficult due to distance and concerns of intellectual property. Logistically it is easier to stay within the South Dakota regental system. Doing an internship would prolong their academic career."

"There is not a large base of chemical engineering opportunities in South Dakota. How do we build internships for our graduate students? How can industry improve our research? Can we learn from the two cultures? Do the students need 8 courses in theory or should have more applied courses?"

"Be careful with collaborations. Make sure they are as committed as we are in working together."

IGERT governance meeting. (1 respondent)

"Change the student governance meetings to a less frequency as it is difficult to get together."

Salary. (1 respondent)

"Consider increasing salary levels again so we can be even more competitive with industry; enable salary levels to be more competitive with industry. Certainly competitive with graduate stipends, but we're trying to keep people here that are typically attracted to industry."

Recruitment assistance. (1 respondent)

"NSF requires citizens to be true IGERT students... we tend to get 20-30% of our pool as US citizens out of 12-15 grad students per year. A lot of dominos have to fall... have to like the project, be here at the right time, be interested... it would have been helpful to have someone to recruit/sell the IGERT program at the SD schools that were involved. Maybe weave into a nationally known program that people could apply to... or at least indicate interest, and upload their CV, we could review them... then I could be in contact with people that I know I could then get on them. If I had the "lead" then I could follow that "lead".

Outreach projects. (1 respondent)

"Students have a lot of group projects through outreach projects. If we should do it over again, we would put more money in the outreach budget. We did not anticipate the scale of the enthusiasm for the projects."

Campus Rotation. (1 respondent)

"Although it was easier to pull a proposal of SD institutions together, it is a little limiting to just collaborate within the state of South Dakota. My student went to Penn State and had a great experience with outcomes. Could we expand collaboration?"

IGERT COORDINATOR FEEDBACK

Both the students and faculty mentioned the role of the IGERT Coordinator. The evaluator interviewed the Coordinator about the SD IGERT program from her perspective.

■ **What is role of the IGERT Coordinator?**

- Assists the PI in budget coordination.
- Assists the PI in grant reporting and management. For example, tracking publications and presentations.
- Performs as a translator between faculty and students.

- Assist students at conferences with logistics, poster presentation, and symposium coordination.
 - Coordinate the outreach activities and travel with the students to assist with coordination and execution of the outreach projects.
 - Leverage position to do complementary projects.
- **From the viewpoint of the Coordinator, what processes should be changed with similar programs?**
- **More outreach components.** There is a lot of opportunity to go into schools and target a) 8th graders and younger; and b) high schools. The IGERT students can influence college decisions. For example, hold an afternoon workshop for high school students. Answer questions regarding engineering and science so they can decide if that is what they want to do.
 - **Out-of-state students.** The IGERT stipend was off-set by out-of-state tuition. Can there be additional compensation for the out-of-state students so they can take as many trips as the in-state students?
 - **Rotations have varied greatly.** Some rotations were very beneficial and resulted in a publication and contributed to their thesis. Other times the rotation was not long enough. The logistics of training, passwords, keys, etc. limited the amount of time doing experiments. They do get housing during the rotation.
 - **Coordinator position.** Hard to coordinate with three campuses without point-of-contact people. Need to find other secretaries from other two campuses to a) aid in communication; and b) track spending.
 - **Periodic check-in with all campuses.** We should check in with all PIs on the Access Grid. Yearly check in to check status on the overall grant and each of the projects. Invite faculty and students update everyone on what is going well and opportunities for improvement.
 - **Social media.** We have a private and public Facebook page. The private side is very casual. We have found more people respond via Facebook than e-mail. Should IGERT and similar programs invest in Twitter?
 - **IGERT website – SDIGERT.org** We include statistics and outreach projects. Student B posted a video. Not the same as the national group recognizing you.
 - **Grant reporting.** The report template is very limiting. She wishes they would ask more questions on the reports. For example, what else have you accomplished? This has a more wide-ranging impact than just publications and presentations.
 - **Nation-wide IGERT.org.** They did start an online group for coordinators via e-mail and message boards. It does not get used much but it is nice to have as a resource. We have been able to post stories there. There is a lot of potential there. All programs should be required to use.

IMPACT ON INSTITUTIONS

Programs such as IGERT not only have a transformative effect on individuals but also on participating educational institutions. The evaluator interviewed three administrators from each South Dakota IGERT university to better understand the impact of IGERT on their institution. In addition, the evaluator interviewed the PI, Dr. Berry, as he had a global view of the program across the state.

- **How have IGERT projects influenced institutional culture and support for interdisciplinary graduate education?**

“The IGERT project was a great investment by the National Science Foundation to South Dakota and its universities. Most small grants fund one professor and one MS or PhD student to complete one project. The IGERT project had influence on several students and faculty and provided a vehicle to align solar energy

projects. IGERT had a very strong influence on creating collaborations across university lines and disciplines. Disciplines worked together who normally would not have that opportunity – metallurgical engineers, nanoengineers, chemists, electrical engineers.”

“IGERT would not have happened without the success of NSF PANS; it was a pre-existing condition. There was support built in; it was a requirement for PANS and the infrastructure that was in place.”

“The IGERT program has raised awareness regarding research in the State of South Dakota and at USD. The collaborative projects amongst laboratories around the state has been productive and positive. Dr. Berry is very good at developing collaborations. Because of her, we were able to get the IGERT grant.”

“The Nebraska Indian Community College chemistry course projects were very impressive. They gained very extensive experience in developing a course from curriculum development, delivery in person and on video conference. They had 6 students. It was a very good experience and the students now have a good background. It expanded their cultural experience beyond USD and gave them exposure to the tribal culture.”

■ **How do IGERT faculty differ from non-IGERT faculty in terms of their teaching, research, mentoring, networking, and productivity?**

“Overall, there is not a drastic difference between non-IGERT and IGERT faculty with two exceptions:

1. **Teaching.** The IGERT faculty teach courses to an interdisciplinary audience. They have had to bring greater clarity and adjust language so the students in the class who are not in that discipline understand and can apply the course content. This is good for faculty to do during their academic career. Super opportunity for faculty and students (2 respondents)
2. **Networking.** The IGERT grant provides a vehicle to talk to their science and engineering peers at the three universities.

Research and productivity are the same for IGERT and non-IGERT faculty members.”

“The people that gravitated to IGERT and PANS had “collaboration in their DNA” – it is a reflection of something that was already in place. If the relationships weren’t authentic to begin with, it all would have fell apart. Many people look at collaboration differently; recognition that each individual is part of a chain... that networking relationship has to exist – you can’t make that up. We are building a network with this.”

■ **How have IGERT projects impacted institutional policies and procedures?**

“The only policy IGERT impacted is regarding how much graduate students are funded. The South Dakota Board of Regents have a policy where graduate students’ stipends are capped at 2/3 tuition. The IGERT grant provided for full tuition. The university presidents can allow for exemptions – and did for this project. The strong financial support was influential in keeping students on the Ph.D. path.”

“There have been some multidisciplinary projects in the past that haven’t fared very well. SDSM&T has a nano-program; going well. A long time ago USD and SDSM&T had a program that didn’t go as well. Inter-institutional programs struggle. However inter-disciplinary people seem to get; think that is why IGERT and PANS was so successful. Each chemistry department has different strengths – we use each other to create a whole. In that sense, we get it – the challenges in front of society are bigger than any one discipline. There is still plenty of work to be done at the individual investigator level, but the big issues (and what is being funded now) are starting to become awfully broad for only one person to have the expertise in for both content domain

and techniques needed to do the job. The EPSCoR philosophy has always been this; we need to rely on the resources of the entire state, because none of us are large enough to be able to do that."

■ **How have IGERT projects impacted institutional structures?**

IGERT did not impact institutional structures. (2 respondents)

IGERT did impact institutional structures. (2 respondents)

"We need to recognize the achievement that IGERT was to the State; a credit Mary Berry - IGERT PI. It is the first of its kind in our State. A great bunch of people to work with; they "got it" – the idea of collaboration. I think that is why that group was successful – it's nice to see some of them moving up to leadership positions; it may not be a direct outcome of IGERT, but it is a reflection of the culture built and fostered across the State that IGERT was a part of."

■ **What elements of IGERT projects have been institutionalized or adopted by other institutional programs?**

Offer interdisciplinary courses.

"Although IGERT did not pay for the capital infrastructure for the Access Grid, IGERT certainly took advantage of the Grid by using it for courses, student presentations, and seminar speakers. Travel is expensive and difficult across the state and the Access Grid helped facilitate learning and work. We will continue to use this resource for interdisciplinary courses."

Leverage IGERT basis and collaboration for additional grant projects.

*"Indirectly, faculty are using the IGERT established protocols to generate other multi-disciplinary projects."
"The collaboration between institutions has led to other grants such as the REU SPACT (Security Printing and Anti-Counterfeiting Technology), Partnerships for Innovation grant, and several NASA grants."*

"New grant proposals are keeping a lot of the same elements including shared courses across campuses and campus rotation." (2 respondents)

.Continue outreach programs.

"Through the REU program, we will continue working with tribal colleges to encourage other students to go into chemistry."

■ **Additional Comments:**

"In the NASA grants, students are visiting and working in NASA labs. We learned that a faculty member needs to make the connections with national laboratories to secure internship positions for graduate students. One of the IGERT students did work at a NASA lab under NASA funding. The original plan was to have students work at national laboratories such as Argonne and NREL. However, they did not take on any students."

"The IGERT graduate program is phenomenal – the stipends are a draw for Ph.D. candidates."

"The IGERT students may go too far with extracurricular activities such as outreach activities. The organization and facilitation time takes away from research. I would not want to take time away from research."