Final Report for Period: 06/2009 - 05/2010 **Submitted on:** 08/31/2010
Principal Investigator: Oliver, Sylvia A. **Award ID:** 0757292
Organization: Washington State Univ
Submitted By:
Oliver, Sylvia - Principal Investigator
Title:
Biotechnology Education Infusion Program

Project Participants

Senior Personnel

Name: Lightfoot, Donald
Worked for more than 160 Hours: Yes
Contribution to Project:
Donald Lightfoot is supported by a consulting contract under the ATE grant. He assists with management of the project, and is responsible for coordination of involvement of industry partners and mentoring of BEI participants.

Some specific activities during the past year:

- Set up all of the industry tours and arranged the itinerary and accommodations for the Phase I field trip to Seattle, WA
- Assisted in the recruitment of teachers and counselors for the Phase I workshops.
- Performed assessment of teacher laboratory skills in biotechnology.
- Assisted in the establishment of the BEI listserve for communication between BEI project staff and participants.
- Mentored high school teachers and students in molecular biology techniques.
- Met with industry partners to set up the Phase II laboratory experiences for summer 2008.
- Participated in reconnect conferences with teachers in Spokane.
- Recruited, evaluated and selected candidates for Phase II laboratory experiences.
-Taught a five-week graduate level research workshop/course for four high school teachers and 8 high school students.
- Coordinated Phase III five-week industry internships for four Phase II teachers.
-Participated in BEI staff meetings throughout the year.

Name: Oliver, Sylvia
Worked for more than 160 Hours: Yes
Contribution to Project:
Sylvia Oliver is supported 40% by the ATE grant since her transition from Co-PI to PI in June 2007. See description of activities under her status as PI.

Name: Oliver, Sylvia
Worked for more than 160 Hours: Yes
Contribution to Project:
During 2007, Dr. Oliver assumed the responsibilities of PI on the previously awarded NSF Advanced Technological Education grant in June of 2007. This required a transition of the grant from Spokane Community College to Washington State University Spokane involving the submission of numerous summary reports, a complete redraft of the budget for the final two years of the grant, closing the grant at SCC, and resubmitting the grant through the NSF FastLane system. The entire process took over seven months to complete. During this transition, Dr. Oliver relocated the two-week Phase I BEI Summer Institute to the WSU Spokane campus, reorganized teaching responsibilities, and assumed greater organizational and administrative responsibilities due to the loss of the former PI.
Dr. Oliver has been responsible for the overall management of the program including meeting goals and objectives, chairing Program and Advisory Council meetings and ensuring the program proceeds in a timely manner consistent with program guidelines since June 2007.
She is also responsible for all purchasing functions and collaborates with project personnel, NSF personnel and WSU administration in decision making on the project.

Some specific activities during the past year:

- Coordinated planning and logistics for Phase I workshop activities.
- Recruited teachers and counselors for the Phase I workshop.
- Led a team of teachers in Phase I hands-on laboratory exercises.
- Performed assessment of teacher laboratory skills in biotechnology.
- Attended the annual ATE conference in Washington DC (Oct 2008)
- Presented a conference workshop the NSTA national conference (March 2008)), talk at a regional grant writing workshop (Sept 2008), talk at the ATE Principal Investigator's annual conference (Oct 2008), and a conference workshop at the Teachers of Teachers of Science annual conference (May 2009)..
- Mentored high school teachers and students in inquiry pedagogy and laboratory techniques.
- Gave 29 biotechnology workshops to high school and middle school students throughout the region reaching nearly 650 students.
- Coordinated BEI project staff meetings.
- Coordinated and participated in Reconnect Workshops with teachers in Spokane and Seattle.

Name: Bassett, Suzanne

Worked for more than 160 Hours: Yes

Contribution to Project:

Suzanne Bassett is supported by a consulting contract through Spokane Community College under the ATE grant. She assists with management of the project, and is responsible for coordination of involvement of Spokane Community College and mentoring of BEI participants.

Some specific activities during the past year:

- Assisted in the coordination, planning and logistics for Phase I workshop activities.
- Led a team of teachers in Phase I hands-on laboratory exercises.
- Performed assessment of teacher laboratory skills in biotechnology.
- Assisted in the establishment of the BEI listserve for communication between BEI project staff and participants.
- Mentored high school teachers and students in molecular biology techniques.
- Brought three high school classes to Spokane Community College to have them conduct PCR labs (BioRad GMO and DS180) with community college students.
-Participated in BEI staff meetings throughout the year.

Post-doc

Graduate Student

Undergraduate Student

Technician, Programmer

Other Participant

Name: Schultz, Debra

Worked for more than 160 Hours: Yes

Contribution to Project:

Ms. Schultz replaced Mr. Howard Waterman as Institute Coordinator and K-12 teacher liaison. Ms. Schultz brings over 20 years of experience in inquiry teaching methods and professional development training of K-12 teachers. She has received national awards for her science teaching and was chosen as a science teaching coach in School District 81 (30,000 students). Ms. Schultz worked closely with Dr. Oliver in organizing and supervising professional development activities for one of the laboratory sections offered during the Phase One workshop. She has also been responsible for ongoing support of the teachers through phone, email contacts, and coordination of the Reconnect Workshops. Ms. Schultz is supported through grant funds.

Name: Knuth, Randy

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Knuth has led the evaluation activities of this project to determine impact and cost effectiveness, in addition to providing data to promote continuous improvement. Dr. Knuth attended regularly during the two-week summer Phase One workshop. He has conducted pre- and post-workshop surveys; coordinated with teachers to have students complete online pre-surveys; attends all ATE staff meetings; attended both Reconnect Workshops for teachers and counselors to distribute and explain student pre-survey findings; and is currently visiting participating teacher's classrooms. Dr. Knuth has been instrumental in providing critical formative feedback to the staff and in gathering extensive qualitative and quantitative data to allow the investigators to determine the effectiveness and impact of the grant activities. Dr. Knuth is supported through grant funds.

Name: Waterman-Steggell, Krysta

Worked for more than 160 Hours: Yes

Contribution to Project:

Ms. Waterman-Steggell assisted all program staff with administrative support to ensure successful coordination and implementation of grant activities. Ms. Waterman-Stegell was supported through grant funds.

Name: Bhuta, Prakash

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Bhuta, biology faculty at Eastern Washington University, co-coordinated the five-week 2008 Phase II research experience for high school teachers and students. He developed the research project, taught teachers the basic laboratory skills required to successfully complete the project, assisted in the literature club (review and presentation of related research articles), and helped teachers and students prepare and make final written and oral presentations.

Name: Miller, Scott

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Miller, Division of Biology faculty at the University of Montana, coordinated a five-week 2008 Phase II research experience for one high school teacher and two high school students. He developed the research project, taught the basic laboratory skills required to successfully complete the project, assisted in the literature club (review and presentation of related research articles), and helped the teacher and students prepare and make final written and oral presentations.

Name: Sylvester, Steve

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Sylvester, biology faculty at Washington State University Vancouver, coordinated a five-week 2008 Phase II research experience for two high school teachers and four students. He developed the research project, taught teachers the basic laboratory skills required to successfully complete the project, assisted in the literature club (review and presentation of related research articles), and helped teachers and students prepare and make final written and oral presentations.

Research Experience for Undergraduates

Organizational Partners

GenPrime Inc

GenPrime staff attended the Reconnect Workshops during which teachers and counselors presented updates of BEI activities in their schools. GenPrime provided mentoring for summer research experiences for teachers and their students during the 2007 and 2008 Phase Two projects. GenPrime also provided a mentored Phase Three summer 2008 research experience for one teacher (M. Dykstra). The Chief Technical Officer (J. Fleming) has participated on the Advisory Council from 2006-present.

MatriCal, Inc.

MatriCal provided mentoring for summer research experiences for teachers and their students during the 2007 and 2008 Phase Two projects. The CEO (D. Roark) participated on the Advisory Council 2006-present. MatriCal also provided a mentored Phase Three summer 2008 research experience for one teacher (D. Field).

Central Valley School District

Central Valley School District is continuing to support delivery of BEI Institute materials into high school and middle school classes by participating teachers (n = 8) and counselors (n = 2). All teachers actively participated in several BEI activities over the course of the grant period (reconnect workshops, field trips, conferences, BEI minigrants, E Daugherty workshop). BEI labs and materials have been infused into high school chemistry and basic biology classes; and also into 7th and 8th grade middle school science classes in three middle schools (Evergreen Middle School; North Pines MS; Bowdish MS). All teachers applied for and received BEI minigrants to purchase biotechnology equipment and supplies to ensure sustainability of the BEI program. Two science teachers at North Pines middle school, an extremely high needs school, have organized two science career awareness events as a direct results of this grant. These events, attended by over 300 students and their families, have been so successful that they are now planned as an annual event. BEI project staff used school resources to present biotechnology workshops for the past two years at two of the three middle schools; and BEI project staff participated in the career awareness event. We consider the two North Pines Middle School teachers to be BEI teacher leaders. This school district embraces the importance of presenting biotechnology career information (by counselors) and hands-on lab experiences (by teachers)as is evidenced by their permission to allow teachers to use school resources to infuse enrichment materials in the classroom and during afterschool programs.

Shadle Park High School

Spokane School District 81 and Shadle Park High School continue to support delivery of BEI Institute materials into high school classes by participating teachers (n = 3) and counselors (n = 3). BEI labs and materials have been infused into basic biology classes and advanced placement classes. One teacher, Dan Dunlop, participated in both the Phase Two and Phase Three programs, bringing added lab resources, career information and new lab experiences to his students. Two teachers, D. Dunlop and H. Mendoza, actively support and participate in new program planning for future grant applications that will expand and sustain the BEI project. Mr. Mendoza has developed a new curriculum for a Special Research Topics course that will incorporate BEI materials and labs. Both teachers applied for and received BEI minigrants to purchase a thermocycler to enhance the BEI curriculum and labs. We consider both to be part of the cadre of BEI teachers leaders.

East Valley School District #361

East Valley School District and Mountain View Middle School are supporting delivery of BEI Institute materials into middle school classes by participating teachers (n = 3) and counselors (n = 1). BEI labs materials have been infused into an advanced high school science class as well as a middle school science course. In 2009, D. Smith brought his middle school science class to WSU Spokane CityLab for a day-long biotechnology workshop. G. Barlow, high school science teacher, participated in the 2008 Phase Two program. He also received a BEI minigrant to purchase biotechnology equipment for his classroom and received approval from his principal to offer a biotechnology course starting in 2010, all the direct result of their participation in the BEI program.

Bethel School District

Bethel School District (Spanaway Lake Junior and Senior High Schools) are supporting delivery of BEI Institute materials into middle and high school classes by participating teachers (n = 3). This district enrolls high numbers of free and reduced lunch students and the BEI program is an opportunity for these students to experience career information they would not otherwise have. BEI labs and materials have been infused into middle school science classes and high school basic biology classes by participating teachers, with activities spanning the three years of the grant. In addition, BEI project staff used school resources to present biotechnology workshops to middle school students.

Missoula County Public Schools

Missoula County Public Schools and Big Sky High School are supporting delivery of BEI Institute materials and labs into their integrated science high school classes by the participating teacher (n = 1). This teacher also participated in Phase Two (2007) and continues to actively infuse BEI resource materials and activities into several high school science courses. She participated in the summer 2008 BEI workshop sharing her experiences as a BEI teacher leader with new Phase One teachers; she attended all reconnect workshops that were held over 250 miles from her home; and she participated in the final two-day biotechnology workshop presented by E Daugherty. She applied for and received a BEI minigrant to purchase a bioimaging system to enhance her biotechnology curriculum. Her school has allowed her to fully integrate BEI labs and curriculum into her classroom, and to involve other science teachers in utilization of BEI materials.

Mead School District 354

Mead School District and Mead High School are supporting delivery of BEI Institute materials into high school classes by participating teachers (n = 2) and counselors (n = 1). BEI labs and materials have been infused into basic and advanced biology classes. One teacher (R.Campanella) participated in both Phase Two and Phase Three and incorporates BEI materials and active research into his classroom. Ryan shared his student research project with new Phase One teachers during the 2008 BEI workshop. Both teachers applied for and received BEI minigrants to purchase biotechnology equipment to enhance their biotechnology curriculum. We consider Mr. Campanella to be one of our BEI teacher leaders.

Lakeside High School

Nine Mile Falls School District and Lakeside High School are supporting delivery of BEI Institute materials into high school classes by participating teachers (n = 2). Both teachers actively incorporate BEI materials into science labs and into their curriculum. One teacher (T. Sardinia) is now offering authentic research experiences for her students as a direct result of the BEI program; and is designing advanced biotechnology labs for her classes. D. Field participated in both Phase Two and Phase Three programs and, as such, was able to bring donated lab materials and equipment into this small high school. Both teachers applied for and received BEI minigrants to collectively purchase a new thermocycler to enhance their biotechnology lab curriculum. We consider both to be BEI teacher leaders who will continue to infuse BEI career information, curriculum and lab activities into their classrooms.

Seattle Biomedical Research Institute

SBRI provided staff time and resources to conduct tours of their research and education facilities to teachers and counselors during the 2006-2008 BEI summer workshops. SBRI advances global health through infectious disease research focused on new drugs, vaccines and diagnostics. The walk-through tours of labs included brief presentations by the faculty conducting infectious disease research. SBRI has also encouraged teachers to bring their students (six BEI high schools 2007-2008) to SBRI for extended day-long tours of the facilities and hands-on lab experiences. As a direct result of the BEI grant, project staff were able to schedule a separate tour by the SBRI facilities manager for the Spokane Skill Center to offer them guidance during their planning stages for a new biotechnology classroom/lab.

Washington Technology Center

WTC provided staff time and facilities to conduct tours for teachers and counselors during the 2006-2008 BEI summer workshops. This organization embraces the value of educational enrichment for teachers to instill interest in students to pursue careers in STEM, with special emphasis on biotechnology.

Fred Hutchinson Cancer Research Center

The Fred Hutchinson Cancer Research Center provided staff time and facilities to conduct tours for teachers and counselors during the 2006-2008 summer BEI workshops. This organization embraces educational enrichment for teachers and counselors to be able to instill in their students interest in STEM careers, including technical biotechnology careers.

Hollister Stier Laboratories

Hollister Stier provided staff time and facilities to conduct tours for teachers and counselors. This biotechnology business provided various lab materials for teachers who participated in Phase Two of the BEI project. Hollister-Stier also provided a mentored Phase Three summer 2008 research experience for one teacher (D. Dunlop). In addition, Dr. David Burkart, senior staff, has been a member of the BEI Advisory Council 2006-present.

Seattle Genetics

Seattle Genetics provided staff time and facilities to conduct a tour for teachers and counselors during the 2007 summer BEI workshop. Seattle Genetics, Inc. is a clinical stage biotechnology company focused on the development and commercialization of monoclonal antibody-based therapies for the treatment of cancer and autoimmune disease. The tour included a walk-through of the laboratories with descriptions of projects and responsibilities of personnel. Also included was an hour-long presentation by HR staff and senior researchers who are heading projects and developing products for clinical trials.

Sonus Pharmaceutical

Sonus Pharmaceutical provided staff time and facilities to conduct tours for teachers and counselors during the 2006-2007 BEI workshops. Sonus Pharmaceuticals is focused on the development of oncology drugs that provide better therapeutic alternatives for cancer patients, including improved efficacy, safety, and tolerability, and are more convenient to use. The tours included walk-throughs of research, production and animal facilities as well as presentations by senior researchers of specific projects, clinical trials and personnel needs of the company.

UW Genome Science Center

The UW Genome Science Center provided staff time and facilities to conduct tours for teachers and counselors during the 2006-2008 BEI workshops. The tours included walk-throughs of the research facilities as well as presentations by the Director of the Center and faculty members of projects being conducted; and description of positions in the Center and the educational pathways required to be able to apply for these positions.

Northwest Assoc for Biomedical Research

The Northwest Association for Biomedical Research has partnered with the BEI project in a number of ways. NWABR has provided a staff person to make presentations during the BEI Phase One summer workshops regarding NWABR's educational programs, including program materials for teachers and counselors. BEI teachers have also attended NWABR professional development workshops to learn laboratory techniques to translate back to their classrooms.

Coeur d'Alene High School

The Coeur d'Alene School District in northern Idaho and Coeur d'Alene high school are supporting delivery of BEI Institute materials into high school classes by participating teachers (n = 2) and counselors (n = 1). BEI labs and materials have been infused into basic and advanced biology classes. One of the Phase One teachers participated in the Phase Two research program (July 2008) and continues to infuse BEI materials into his curriculum. This teacher received a BEI minigrant to purchase micropipettes and other biotech equipment to ensure sustainability of biotech labs. The second teacher who was instrumental in bringing biotechnology into Coeur d'Alene High School has retired.

Joel E Ferris High School

Spokane School District 81 and Ferris High School are supporting delivery of BEI materials into high school science classes by participating teachers (n = 6) and counselors (n = 1). BEI labs and materials have been infused into basic and advanced biology classes. One teacher (head of the science department)participated in the Phase Two program; and all teachers are infusing BEI curriculum and lab experiences into their classrooms. Ferris teachers received a BEI minigrant to purchase biotechnology equipment and supplies to ensure sustainability of BEI program materials/labs. This school has continued to encourage presentation of biotechnology career information (by counselors) and hands-on lab experiences (by teachers)to their students.

Dayton High School, Dayton, WA

Dayton High School, located in a rural farming region of eastern Washington, continues to support delivery of BEI Institute materials into high school classes by a participating teacher (n = 1) and counselor (n = 1). BEI labs and materials have been infused into basic biology classes; and the teacher received a BEI minigrant to purchase biotechnology equipment, micropipettes and an electronic balance to ensure sustainability of BEI curriculum and labs.

Columbia High School

Columbia High School is a small, isolated rural school located in a high poverty region of Washington State where over 1/3 of the student population is Native American. The BEI resources are highly valued and continue to be infused into middle and high school courses. In addition, the BEI teacher (D.Berg) participated in the 2008 Phase Two research program to bring greater resources and more relevant information to her students; attended a professional development workshop on cytometry in 2009; and brings her advanced placement students to WSU Spokane CityLab annually to participate in a day-long advanced biotechnology laboratory taught by Dr. Oliver. Ms. Berg applies for and received a BEI minigrant to purchase biotechnology equipment to ensure sustainability of BEI curriculum and labs. We consider Ms. Berg to be one of our BEI teacher leaders.

Vancouver Home Connection, Vancouver SD

Vancouver Home Connection, located in Vancouver, WA, is a parent-partnered school for families who home school their children and choose this public school option for science. One middle school teacher and one high school teacher who participated in the '07 BEI Summer Institute continue to actively infuse BEI materials into their science curricula. The HS teacher (P. Palmer) chose to participate in the '08 Phase Two research program to provide her students with greater resources and more relevant biotechnology experiences and to gain valuable lab experience to improve science offerings to her classrooms. We consider Ms. Palmer to be one of our teacher leaders who accessed all aspects of the BEI program (reconnect workshops, field trips, conferences, E. Daugherty workshop, BEI minigrant, Phase Two) and actively infused BEI materials and labs into her science teaching program.

Heritage HS, Vancouver School District

Heritage High School located in Vancouver, WA is supporting delivery of BEI Institute materials into high school classes by a participating science teacher. BEI labs and materials have been actively infused into basic and advanced biology classes. This teacher also used BEI funds to take her students on two field trips to the Seattle Biomedical Research Institute in Seattle, WA to experience hands-on biotechnology labs related to infectious diseases. This teacher participated in the '08 Phase Two research program to bring herself and her students greater resources and more relevant biotechnology experiences. She also received a BEI minigrant to purchase biotechnology supplies (her school already has biotechnology equipment) to ensure sustainability of the BEI program. We consider this teacher to be a BEI teacher leader.

Highline HS, Highline School District

Highline High School is a high-needs school located in Burien, WA where over half the students qualify for free and reduced lunch and over

2/3 are students of color. A teacher/counselor team attended the '07 BEI Summer Institute. BEI materials have been used in basic biology courses and for counseling purposes.

Bellarmine Preparatory School

Bellarmine Preparatory School is a private school located in Tacoma, WA. A teacher/counselor team participated in the '07 BEI Summer Institute and infused BEI materials into the science curricula and counseling programs during their first year of participation.

Chase MS, Spokane SD #81

Chase Middle School is a large middle school located in Spokane WA, with a significant high needs student population (40% free and reduced lunch). Two science teachers attended the '07 BEI Summer workshop and one additional science teacher attended the '08 BEI summer workshop. Two of these teachers continue to actively infuse BEI materials and curricula into their classrooms. Both teachers applied for and received BEI minigrants which were used to purchase micropipettes to enhance their biotechnology lab experiences. Both teachers request and receive onging materials and mentoring support from project staff and WSU Spokane Citylab.

Seattle Girl's School

Seattle Girl's School is a small, private school for middle school age students with an emphasis on technology, math and science. One science teacher attended the '07 BEI Summer Institute and infused some BEI materials into her curricula prior to accepting a position at another school.

Whitefish High School

Whitefish High School is a small high school located in Whitefish, MT. One HS science teacher (C. Sullivan) attended the '07 BEI training and continues to actively incorporate several BEI activities into her curricula. She has accessed the WSU equipment loan program, attended the summer '08 BEI workshop to share her experiences with new Phase One teachers, has attended both the '07 and '08 reconnect workshops, and attended the two-day E. Daugherty biotechnology workshop. Ms. Sullivan applied for and received a BEI minigrant to purchase micropipettes to enhance her biotechnology curriculum. We consider Colleen to be one of our BEI teacher leaders.

Oak Harbor High School

Oak Harbor High School is a large high school located in a district with high numbers of students from families in the armed forces, resulting in a high turnover rate within the district. Three counselors and two science teachers attended the '08 BEI Summer workshop. All are actively infusing BEI lab materials, curricula and career awareness materials into their teaching programs. These teachers accessed all the activities and materials provided by the BEI program including lab materials, reconnect workshops, field trips, conferences, two-day Daugherty biotechnology workshop, and BEI minigrants. They used their BEI minigrant to purchase a thermocycler to enhance their biotechnology curriculum. We consider one of these teachers (S. Templin) to be one of our BEI teacher leaders.

Olympia Regional Learning Academy

The Olympia Regional Learning Academy is part of the Washington State public Olympia School District. The Academy supports home-based instruction by providing enrichment classes and resources that are difficult to provide at home; and also provides full or part-time programs for high school students through the Connect Academy. M. Whittaker, a high school science teacher in the Connect Academy, participated in the Phase One BEI workshop and has actively infused a variety of BEI resources into her classroom. She accessed advanced biotechnology lab materials from the BEI program; and she received one of the $10,000 Amgen Award for Science Teaching Excellence. She credited the BEI program for providing her with the background and technical assistance to be able to provide new and challenging labs for her students, thus making her more competitive for awards such as these.

Bonney Lake High School

Bonney Lake High School is a large, public high school, with administrative support for more advanced science experiences for their students, including biotechnology. Both the science teacher and counselor actively infused BEI materials into their teaching and counseling programs; accessed lab materials; participated in reconnect workshops; attended the two-day Daugherty biotechnology workshop; and applied for and received a BEI minigrant that they used to purchase a bioimaging system.

Hanford High School

Hanford High School is a large school largely serving families that work at Pacific Northwest National Laboratory, one of the U.S. Department of Energy's (DOE's) ten national laboratories, managed by DOE's Office of Science. PNNL performs research for other DOE offices as well as government agencies, universities, and industry to deliver breakthrough science and technology to meet today's key national needs. This high school posts some of the highest math and science scores on state standardized tests, yet there was a lack of focus on biotechnology, even after the school purchased essential equipment. The BEI teacher was then able to build a biotechnology program by including BEI labs, lab materials and curricular materials; and enrich the class through a field trip to the Seattle Biomedical Research Institute.

Snohomish High School

Snohomish High School is a large, suburban high school located near Seattle, WA. The BEI science teacher. J. Ingersoll, has participated in all aspects of the BEI program including accessing lab materials and BioRad kits for intermediate and advanced biotech labs; attending reconnect workshops; organizing a field trip to SBRI for her students; attending a professional development workshop on cytometry; receiving a Murdock Partners in Science Grant to work on Heliobackter pilori at Fred Hutchinson Cancer Research Center; and receiving a BEI minigrant to purchase electrophoresis equipment and supplies to ensure sustainability of the BEI program in her school. We consider Ms. Ingersoll to be one of our BEI teacher leaders.

Northwest Christian School

Northwest Christian School is a small, private school located near Spokane, WA. The BEI teacher. K. Eneroth, has been able to incorporate many advanced biotechnology labs into her curriculum and continues to be one of the most active teachers from the 2008 cohort. Ms. Eneroth accessed intermediate and advanced lab materials, BioRad kits, attended reconnect workshops, attended the two-day Daugherty biotechnology workshop, and received a BEI minigrant to purchase electrophoresis equipment to ensure sustainability of the BEI program in her school. We consider Ms. Eneroth to be one of our BEI teacher leaders.

Kirkland Junior High School

Kirkland Junior High School is a small suburban school located near Seattle, WA. The BEI teacher has participated primarily through NSTA conference attendance and attendance at the Feb Reconnect Workshop. A second BEI teacher moved into the Lake Washington School District to teach high school science, and these two teachers are now working together to create 'pipeline' lab experiences to give students better foundations in biotechnology as they move from middle school into the high school setting. Both teachers accessed lab materials; and the high school teacher received several BioRad kits and also received a BEI minigrant to purchase bioetchnology equipment for his classroom.

Century High School

Century High School, located in Hillsboro, Oregon (near Portland, OR), is a medium to large suburban school. The BEI teacher, R. Carnes, has developed creative CSI and anatomy/physiology courses in her high school and attended the workshop to obtain more advanced biotechnology lab experiences for her students. Ms. Carnes received lab materials and advanced BioRad kits, attended reconnect workshops and the two-day Daugherty biotechnology workshop, and received a BEI minigrant to purchase equipment and supplies to sustain her biotechnology program. We consider Ms. Carnes to be one of our BEI teacher leaders.

Wellpinit High School

Wellpinit High School is a small, isolated, rural school located on the Spokane Indian Reservation in eastern Washington. This school serves large numbers of undeserved Native American students (70%) and struggles to meet state academic standards. The BEI teacher, B. Reynolds, is a high school science teacher and is one of the most active, if not the most active teacher from the 2008 cohort. She has incorporated both introductory and advanced biotechnology labs, has taken her students on field trips to local universities, introduced students to bench research projects, participated in regional science conferences (supported through BEI), and provides ongoing career information in STEM and biotechnology to her students. The superintendent strongly supports all of these activities as crucial to student success. We consider Ms. Reynolds to be one of our BEI teacher leaders.

Saint George's School

Saint George's School is a small, private school located in Spokane, WA. Two high school teachers (science and math) and one counselor attended the 2008 BEI workshop. All have been active participants incorporating both lab materials and curriculum into their courses. The science teacher has received both lab materials and BioRad kits, all have attended reconnect workshops, all attended a Vernier workshop, the two teachers attended the two-day Daugherty biotechnology workshop, and all received a BEI minigrant to purchase Vernier Probe equipment. The administration supports the BEI program at St. George's, including a fund raiser to purchase biotechnology equipment to sustain the program after the grant ends.

Other Collaborators or Contacts

The Riverpoint Partnership for Math and Science (RPMS), a collaboration of three public institutions of higher education in eastern Washington (Washington State University, Eastern Washington University, Community Colleges of Spokane), the three largest school districts in the region (Mead School District, Central Valley SD and Spokane Public Schools), and the eastern Washington Educational Service District (ESD 101). The mission of RPMS is to improve math and science education and advance best practices in math and science instruction so more students leave high school well-prepared for rigorous college coursework and for careers in math, science, engineering, and health sciences. The BEI project staff work with members of the RPMS to exchange and promote best practices and to collaborate on future projects and funding opportunities.

Teaching and Learning Services, Career and Technical Education (CTE) Program (Spokane Public Schools). A collaborative relationship has been formed with the CTE program to create biotechnology-focused courses. A new course, Introduction to Health Careers, has been approved for the 2010-2011 school year. This course incorporates one full unit dedicated to biotechnology, with hands on activities developed through the BEI project. In addition, this collaborative relationship resulted in the award of a state-funded Health Science Career afterschool program for middle school students in Spokane. This program was designed to incorporate the hands-on biotechnology unit refined during the BEI project. In addition to health careers, students were introduced to a variety of biotechnology career options.

The Spokane Skill Center (SSC). SSC offers diverse career oriented programs for high school students from 11 school districts in northeastern Washington. As a result of BEI school activities and developing relationships with school districts, BEI project staff were invited to participate in the creation of a biotechnology program at SSC, including design of a 2,000 sq ft lab/classroom space dedicated to biotechnology. In addition to this collaboration, Dr. Oliver continues to provide annual biotechnology field trips to students enrolled in the SSC Clinical Science Investigation program.

Spokane Area Workforce Development Council (SAWDC). Members of key industry sectors of our regional economy are dedicated to supporting job creations, closing skills gaps, improving productivity and developing a highly responsive workforce system. As such, SAWDC promotes K-12 education and training initiatives, and workforce training programs. Dr. Oliver was invited to serve on the Workforce Advisory Council to provide expertise in K-12 STEM programs including an emphasis on biotechnology.

Dr. David Lin, Associate Professor, School of Chemical Engineering and BioEngineering, Washington State University. The BEI grant team has worked with Dr. Lin to develop outreach projects for BEI students related to his research on hibernating bears. A group of Native American high school students from Wellpinit High School were taken on a field trip to the WSU campus in Pullman, WA, where they toured Dr. Lin's lab, observed the research bears at the College of Veterinary Medicine, and learned about Dr. Lin's research program. If funds are obtained, these students will analyze muscle biopsies for proteins of interest.

Dr. Andrea Castillo, Assistant Professor, Biology Department, Eastern Washington University. We are developing collaborative relations with Dr. Castillo to create research opportunities for teams of graduate, undergraduate and high school students. Dr. Castillo's area of research is bacterial conjugation in Heliobacter pylori.

Ellyn Daugherty. The BEI grant team is working closely with Ms. Daugherty to help BEI teachers develop biotechnology programs at their high schools. A 27 ?year veteran biology teacher, Ellyn Daugherty has taught biotechnology since 1988. She is the author, Lead Teacher, and Program Administrator for the San Mateo Biotechnology Career Pathway (www.SMBiotech.com). Her model curriculum attracts adults and teenagers into an intensive, multiple-year program in biotechnology that leads students to higher education and the workplace. Ms. Daugherty was the featured speaker and workshop facilitator at the 2009 BEI culminating conference attended by 30 BEI teachers. All teachers received complete curriculum packages including a Course Planner, Instructor's Guide, Student Handbook, and Laboratory Manual. As a result of the BEI Program and Ms. Daugherty's workshop and curriculum, one BEI teacher leader developed and received approval to offer a biotechnology course at his high school. Two other teachers are in planning stages to create biotechnology/research courses in their high schools.

Greater Spokane Incorporated (GSI), Spokane's Chamber of Commerce and Economic Development Council, is collaborating with WSU Spokane and WSU Spokane CityLab in support of WSU Spokane's new role as National Affiliate for the Project Lead The Way Biomedial Program. Numerous aspects of the BEI Program positioned WSU Spokane competitively for this role, including the selection of Dr. Oliver as the Affiliate Director, largely based on her experience as PI for the BEI Program.

The Spokane Math Engineering Science Achievement Program (MESA) serving K-12 students of color and young women to encourage and prepare them for STEM education and career pathways. MESA is collaborating to with WSU Spokane CityLab to provide their middle and highs school students with BEI-prepared biotechnology experiences. MESA teachers also access BEI-prepared curriculum and career information for their students. Dr. Oliver is Co-Chair of the MESA Advisory Board and works closely with the MESA Director to identify and prepare grant applications, especially those that will leverage the resources and teacher network established through the BEI grant.

Activities and Findings

Research and Education Activities:

Research and Education Activities:

Program Goal and Objectives. Implement and evaluate a three-phase Biotechnology Education Infusion (BEI) program to assist science teachers and career counselors to effectively deliver information about biotechnology career opportunities to students, leading to enhanced student knowledge about the industry, enhanced laboratory skills sets, and an increase in the numbers of students entering the biotechnology work force. Objective 1: Recruit and train regional high school (HS) and community college (CC) science teachers and career counselors through a two-week BEI Phase One Summer Institute; a five-week BEI Phase Two research program; and a five-week Phase Three industry internship. Objective 2: Implement the school-based BEI program and assist teachers and counselors to compile a BEI Resource Guide including career advising materials, instructional materials, and laboratory investigations. Objective 3: Determine the efficacy of BEI program goals through formative and summative evaluations. Objective 4: Disseminate the BEI Resource Guide and BEI Program Model.

Summary of Research and Education Activities:

This section includes cumulative overviews of the BEI program implemented between June 2006 to May 2010 including: Phase One, Two and Three programs; annual Reconnect Workshops, WSU Equipment Loan Program, BEI Listserve, and consultation/support from the BEI grant team. More detailed information related to each of these program activities is included under Training and Development.
Phase One BEI Summer Institute: Sixty-nine middle and high school science teachers and 19 counselors attended the three Phase One BEI Summer Institutes. The participants came from a wide range of schools: public (large urban and suburban, medium suburban); high free and reduced lunch student populations; high Native American student population; high percentage of students of color; small, public home-school; private; and private Christian. Teachers came from three states (Washington, Oregon and Idaho). The grant team replicated as closely as possible successful activities and tours to ensure a uniform experience for all participants. Week One was held on the WSU Spokane campus, and Week Two laboratory experiences were presented at Spokane Community College. A new addition to the program on the first day of the Phase One Institute during Year Three was a 'Biotech Boot Camp' to provide teachers and counselors a basic understanding of biotechnology, its applications, and wide range of career opportunities for students. A two-day trip to Seattle, WA (the largest city in Washington State and home to nearly 200 biotechnology companies and research organizations) was organized to introduce teachers and counselors to small, medium and large companies and research organizations. They came away with a much better understanding of the types of jobs available to well-prepared students. This two-day field trip had a significant impact on both counselors and teachers. The remainder of the first week in Spokane included talks from industry representatives, reports from previous Phase One teachers and counselors and current Phase Two BEI teachers, time to create career brochures, and planning for activities for the coming school year. Week Two included hands-on biotechnology labs teachers could use in their classrooms. Teachers chose either an introductory track (primarily for middle school and early high school teachers); or the advanced track for teachers who had prior experience with biotechnology labs. The week ended with presentations of research projects by Phase Two teachers and students, and planning for laboratories and other activities during the coming year. More detailed information about Phase One activities is included in the Training and Development Section.
Phase Two BEI Summer Research Experience. Thirteen Phase One teachers who integrated labs and biotech instruction in their classrooms during the year immediately following the Phase One BEI Institute continued their involvement in BEI as Phase Two teachers during Years Two and Three. Twenty-eight high school students also participated in the Phase Two research experience. Nine of the twelve teachers gained their research experiences under the direction of Dr. Don Lightfoot on the Eastern Washington University campus; one teacher worked with Dr. Scott Miller on the University of Montana campus in Missoula, MT; and two teachers gained their research experiences with Dr. Steve Sylvester on the Washington State University Vancouver campus. Over a five-week period from early July to mid-August, teachers were trained and performed biotechnology research. The research was a significant part of ongoing university faculty research. To exercise the teachers' ability to learn, and then to immediately teach the same methods and concepts, each teacher invited two of his/her students for the latter four weeks of the training session. The goal was to build experience and confidence in the teachers in biotechnology applications and methods in the hope the experience would translate into much greater enthusiasm and competence of the teachers in the classrooms. Each teacher was appraised of the research and its purpose a month prior to the start of the five-week session. During the first week, teachers received training in standard lab procedures (e.g. micropipetting, making solution, etc). Teachers were taught the use of all basic microbiology procedures and inoculation methods. Each one determined how to bring these skills to their own classrooms, considering local deficiencies. Each day of the first week also included two formal lectures on the background and mechanics of the research and how to apply it to the high school classroom. During weeks two-four, each teacher prepared his/her students in the research methods they had just learned. Teachers had to help and coach students in the weekly literature clubs, a real challenge for most students. Teachers learned to solve common problems of experiments not working. The final week of Phase Two included a one-day conference in which each team (one teacher plus two students) made a formal presentation of data and its contribution. A published document of abstracts was made and distributed.
Phase Three BEI Summer Industry Internships. Four of the Phase Two teachers continued their involvement in Phase Three. Individual

teachers were placed in different industry settings as employees. The four industry settings were: GenPrime (http://www.genprime.com), MatriCal (http://www.matrical.com), Hollister-Stier Laboratories (http://www.hollisterstier.com/corporate), and Signature Genomic Laboratories, LLC. (http://www.signaturegenomics.com). Each teacher was trained in skills relevant to selected jobs within the company (e.g. MatriCal trained its teacher intern in cell culture techniques) and they performed these jobs for the duration of the five-week internship.
Reconnect Workshops: Two, one-day Reconnect Workshops were held to bring teachers and counselors together to share BEI experiences and materials. Workshops were held on the west and east sides of the state to accommodate teachers from throughout the region. Participants not only learned about the successes and challenges other teachers/counselors were experiencing, but they were also able to interact directly with the BEI grant team for more in-depth consultations on challenges they were experiencing in their school setting. New biotechnology curricular materials (e.g. Biotechnology: Science for the New Millennium) obtained by the BEI grant team were shared. Mid-year surveys were completed by teachers and counselors.
WSU Equipment Loan Program. Teachers were able to access a variety of laboratory equipment from the WSU Equipment Loan Program. This equipment is provided for free, including shipping and handling. During Years One and Two, BEI grant funds were used to purchase two biotechnology equipment kits that will continue to be available to BEI teachers. One kit provides basic biotechnology equipment for beginning and intermediate labs (power supplies, gel boxes, micropipettes, microcentrifuge); while an advanced kit provides a power supply, gel box, micropipettes, microcentrifuge, and thermocycler to allow teachers to conduct PCR labs. This equipment is too expensive for school districts to purchase, especially during the current times of declining budgets. These kits are accessed frequently by BEI teachers.
BEI Listserve. A BEI Listserve was established during Year One, and is used on a regular basis to send current and relevant information to all teachers and counselors. The BEI staff will continue to use this listserve to connect with BEI teachers and counselors providing them up-to-date links, cutting edge research findings, new teaching resources, workshop and field trip offerings, and grant opportunities.
Consultation/Support from the BEI Grant Team. The BEI grant team provided, and will continue to provide, ongoing support to teachers and counselors (on an average, several times a week). Consultation and support included purchase, repackaging and mailing of lab materials and BioRad kits to teachers in all states (WA, OR, ID, MT); providing detailed lab instructions; troubleshooting labs; coordinating reimbursements for travel, stipends, field trips and conferences; coordinating business and industry collaborations; and providing field trip opportunities for students to conduct biotechnology labs with community college student partners. Dr. Bassett helped to coordinate multiple field trips to her teaching lab at Spokane Community College (St. George's School, Nine Mile Falls High School, Wellpinit High School) where high school students worked side-by-side with community college students conducting PCR labs. These experiences proved to be very successful and popular for both groups of students.

Findings: (See PDF version submitted by PI at the end of the report)

Please see the attached file describing cumulative accomplishments and findings.

Training and Development:

The following section describes the training and development for middle and high school teachers offered during Phase One, Phase Two and Phase Three BEI Summer Institute programs:

PHASE ONE BEI SUMMER INSTITUTE WORKSHOP ACTIVITIES: Week One: Teachers and Counselors. Industry specialists and higher education faculty presented current information on biotechnology careers, technology content standards, and career and educational pathways. Biotechnology industry needs specific to the Northwest Region were emphasized. NSF-funded Bio-Link Center of Excellence in Biotechnology, Standards for Technological Literacy, and other previously developed curricular and laboratory materials were used as resources throughout the two-week Phase One workshop. Week One field trips during Years One-Three included tours to nine biotechnology organizations in Seattle, WA (University of Washington Genome Center, the Washington Technology Center, Targeted Growth, Inc., Seattle Biomedical Research Institute, Fred Hutchison Cancer Research Center, Sonus Pharmaceutical, Seattle Genetics, ICOS Corporation, Zymogenetics). Tours included presentations by scientists, technicians and human resource personnel. During the remainder of the week after returning to Spokane, teachers and counselors broke into small discussion groups to review and discuss ways to incorporate information they had learned from the Seattle companies and research organizations into their curricula and career counseling materials. Talks were also presented by previous Phase One and Phase Two teachers about their BEI experiences; and by Phase Three teachers about their industry internship.. Week Two: Science teachers participated in guided biotechnology laboratory experiences representative of industry work environments and were given instructional support on active learning strategies. Due to the wide range of biotechnology lab experiences of teachers attending the Phase One workshop, two different research strands were developed. Strand One was developed for middle and early high school teachers who were interested in learning basic inquiry methods and hands-on biotechnology labs. Teachers learned basic biotechnology labs (Electrophoresis Exploration, The Dye Lab, CSI DNA Lab), learned how to isolate DNA from a variety of sources (e.g. strawberries, peas, wheat germ), conducted a BioRad pGLO lab, and learned how to infuse biotechnology labs into the middle school setting by a Middle School teacher leader. Strand Two teachers conducted three separate laboratory activities. One was based on green-fluorescent protein (GFP) labs representative of a biotechnology industry application that can be easily translated to the regular school classroom. To encourage teachers to implement the GFP laboratory activities into their classroom, each teacher was provided with a BioRad Transformation Kit to genetically engineer E. coli to express the GFP gene. Strand Two teachers also conducted a BioRad GMO PCR lab to determine if store-bought foods have been genetically modified; and conducted a separate PCR lab to determine VNTRs at the D1S80 locus. Practical support for the teachers to encourage implementation of biotechnology lab investigations will continue to be provided by an equipment loan program (basic gel electrophoresis kit including gel boxes, power supplies, pipettes, light boxes, consumables; and an advanced kit including thermocycler, gel box, power supply, pipettes, microcentrifuge, consumables). During the course of the week-long laboratory activities, teachers were given time to work together to discuss how laboratory experiences could be translated to the regular classroom.

PHASE TWO BEI SUMMER INSTITUTE RESEARCH PROGRAM: Over a five-week period from early July to mid August in 2007 and 2008, thirteen experienced high school biology teachers were trained and performed biotechnology research. The research was a significant part of ongoing university faculty research which is being published. To exercise the teachers' ability to learn and to immediately learn to teach the same methods and concepts, each teacher invited two or three of his/her students for the latter four weeks of the training session. The goal was to build experience and confidence in the teachers in biotechnology applications and methods in the hope the experience would translate into much greater enthusiasm and competence of the teachers in the classrooms. Enthusiasm and confident knowledge are palpable qualities, perceived by students, and are effective in inspiring students to enter biotechnology and bio-medical careers. This plan was very successful.

Each teacher was appraised of the research and its purpose a month prior to the start of the five-week session. They also selected students each according to their own criteria. All teachers had participated in the two-week, Phase One introduction to biotechnology the previous summer. Upon arriving at the Swartz Biotechnology Laboratory at Eastern Washington University, the biotechnology laboratory at the University of Montana, or at the biology laboratory at Washington State University Vancouver, teachers were instructed to wear a lab coat, use a bound notebook for all writing, and to be punctual and cooperative throughout. They were given safety training documents, a quiz and, after viewing safety videos, certified in chemical, general, and biological safety procedures. When their students joined in the next week, the teachers provided them with the same training.

At Eastern Washington University, Dr. Don Lightfoot trained ten teacher teams. At the University of Montana, Dr. Scott Miller trained one teacher team. At WSU Vancouver, Dr. Steven Sylvester trained two teacher teams. During the first week, teachers were trained in micropipetting and in standard and automated pipetting. This was a very quantitative and statistically based exercise and it revealed teachers were weak in quantitative skills and experience. They quickly overcame this, working and calculating on their own and then teaching the individual students.

During the first week there were two formal lectures variously on the background of the research, the compelling reasons to do it, the environmental implications, and the molecular genetic tools being used. Of more practical value, other lectures covered the mechanics of the experimental plan, the details, variables and history of each laboratory procedure, quantitative methods of data collection, and data presentation methods. Throughout, each topic was re-visited in terms of how to apply it to the high school classroom. The teachers were very engaged, met and discussed with each other and unanimously asked for more time to work together to better know how to translate the lab work to their poorly supported class labs.

A standard discipline in research is a weekly or semi-weekly literature club in which each person presents a relevant, current research paper. The teachers performed this daunting task as well, at first with concern, and later with pride and excitement. Most of them said they would add the literature club to the schedule in their advanced biology classes. This process overcomes many anxieties and gives a real sense of professional sharing for students and teachers alike.

A perennial shortcoming of beginning researchers is the concepts and methods of making solutions: molar, percent, X-multiples, stock solutions, working solutions, pH, and volumes. Of course, the teachers were very rusty on an intuitive sense of the metric system. Again, teachers, individually, in week one were required to re-learn how to use and make solutions by all of these means. They made several multi-component solutions, checking the calculations several times and validating the resulting solutions for their use in the remaining weeks.

The teachers had a very busy 40 hours in the first week. When students joined in for the remaining four weeks, teachers were quite occupied in transferring the training to them. Forces at play included constantly engaging the attention of the students (they were very successful), inter-school competition (a minor factor), a sense of competence and competitiveness between teachers (a strong force), a desire to please the mentors and university researchers (an excellent motivator), and not wasting time or materials, but ending up with valuable, authentic research data (they all succeeded). Indeed, all but two of the teachers had tried to talk about science and research for years in the classroom, but had never been part of any laboratory research, let alone part of a project of far reaching molecular and ecological implications.

The final week of Phase Two included a one day conference in which each team (one teacher plus two students) made a formal presentation of data and its contribution. A document of abstracts was made and distributed. This program was more successful than anticipated as the assessment data show. Another important demonstration of the success of the Phase Two experience has been requests by six of the seven teachers to participate in the Phase Three industry internship program. At this time, four teachers have been placed in four local, established biotechnology companies for five-week internships.

The following are descriptions of the research projects conducted by teacher-student teams.

Bacteria play an important role in recycling inorganic and organic chemicals in our environment. Application of molecular techniques has allowed the scientists to overcome the requirement of prior cultivation of bacteria. One such method is the analysis of ribosomal RNA genes

(in our case the 16S rRNA gene). A comparison of 16S rRNA gene of an unknown bacterium with those stored in a gene bank would allow one to identify the organism. The goal of this project was to identify different types of bacteria present in the water sample obtained from Medical Lake, WA. DNA was isolated from water samples and the 16S rRNA gene was amplified using gene specific primers and Polymerase Chain Reaction (PCR). The product of PCR reaction was cloned the organisms identified based on their 16S rRNA gene sequence. Medical Lake was selected because of its proximity to EWU's campus, ease with which water samples could be collected, and the fact that it had been studied by the other members of the Biology department over more than a decade.
Two projects dealt with marine bacteria. One involved identification of marine bacteria isolated from a solar salt production facility. These bacteria were isolated from seawater ponds with different salinities. The project dealt with monitoring changes in the bacterial population with increase in salinity of seawater during solar salt production. While on a professional leave for this project, a faculty member isolated marine bacteria producing an extracellular enzyme, Agarase, by enrichment technique. Another project therefore involved isolation of the agarase gene from the marine isolate. The isolated gene and its product (Agarase enzyme) was further characterized by molecular and biochemical techniques. The identification of marine bacteria followed the same strategy as the one used for fresh water bacteria (i.e. analysis of 16S rRNA gene). The isolation of agarase gene involved preparation of genomic DNA, limit-digestion of this DNA with selected restriction enzyme(s), and cloning of the DNA fragments into a plasmid vector to prepare a gene library. The molecular analysis of agarase gene included determination of complete coding sequence (CDS) and its size. For the partial characterization of the extracellular enzyme, standard biochemical techniques of enzyme assay and enzyme purification by ammonium sulfate precipitation were used.

Additional teacher/student projects included the following:
How Quickly does a Soil Bacterial Population Return after Field Tilling?
Microbial Community in an Urban Wet Pond.
Environmental Microbiology of an Urban Vs Rural Site.
Characterization of Soil Bacteria from Urban Grassy Swales.

Skills learned
-Keeping an organized laboratory notebook.
-Searching & reading of technical literature.
-Preparation of stock reagents & buffers.
-Basic microbiological techniques; preparation of sterile media, streak plate & spread plate techniques and aseptic technique.
-Working with enzymes and nucleic acid.
-Working with DNA; isolation of DNA, PCR, gel electrophoresis, blotting, etc.
-Bioinformatics tools; accessing gene bank to obtain gene sequence(s), selecting primers for PCR, sequence comparison (BLAST analysis), etc.

-Biochemical techniques; crude enzyme assay, enzyme purification & characterization.
-Data collection, data analysis and data presentation to peers.

SUMMER RESEARCH PROJECTS ? WSU VANCOUVER
The future of the multi-million dollar oyster industry in Willapa Bay, WA is currently being threatened by burrowing shrimp populations, which naturally make the sediment too soft for oyster culture. Carbaryl has been the pesticide of choice for several decades, but is soon to be banned. Thus the oyster industry is looking for any and all new control agents ? chemical, physical or biological. One important aspect of the basic biology of burrowing shrimp that is very poorly known, however, is the role of predation, especially in Willapa Bay. Burrowing shrimp have been reported to occur in the stomachs of a number of predators. One obvious potential biological control agent, which has a long history within pest management, is to use natural predators (e.g., Kareiva 1996, Lafferty and Kuris 1996 and references therein). The teacher/student research objective was to identify the suite of natural predators, both vertebrate and invertebrate, that prey upon ghost and mud shrimp in Willapa Bay. To do so, a variety of field sampling techniques were learned (e.g. pelagic net sampling, beach seining and fyke net sampling of tidal channels), combined with microscopic dissection and molecular genetic analysis of potential predator gut contents. Teacher/student teams also gained information on the relative importance of the burrowing shrimp within the predators' diet based on DNA content. Only with this information can resource managers make informed decisions regarding possible use of predators as effective biological control agents of the burrowing shrimp. As the shrimp become manageable, the oyster industry can remain a viable economic component of Willapa Bay and the State of Washington. Teacher-student teams in Dr. Sylvester's lab worked to develop an assay to identify Artemia fransiscana (brine shrimp) DNA from Medaka (Oryzias Latipes, Japanese Killifish) digest, two model organisms. Students learned the care of model organisms in the lab setting, mitochondrial DNA isolation methods, and quantitative real time PCR. Teachers and students also learned how to design primers for qPCR. The following were accomplishments attained by teacher-students teams:

-Able to configure proper primers for each DNA sample
-Able to detect which DNA extraction kit worked and which one didn't
-Able to produce flush from Medaka digesta
-Able to produce data that concluded we were able to extract Artemia DNA from Medaka digesta flush and from Herring gut

-Able to run PCR with results
-Able to design experiments to solve problems encountered during the process
-Able to keep fish alive and healthy
-Able to extract Artemia mitochondrial DNA
-Able to maintain composure when experiments failed
-Able to successfully BLAST Artemia

PHASE THREE BEI SUMMER INDUSTRY INTERNSHIPS.
Four of the Phase Two teachers continued their involvement in BEI as Phase Three teachers. Individual teachers were placed in different industry settings as employees. The four industry settings were: GenPrime (http://www.genprime.com), MatriCal (http://www.matrical.com), Hollister-Stier Laboratories (http://www.hollisterstier.com/corporate), and Signature Genomic Laboratories, LLC. (http://www.signaturegenomics.com). Each teacher was trained in skills relevant to selected jobs within the company (e.g. MatriCal trained its teacher intern in cell culture techniques) and they performed these jobs for the duration of the five-week internship. The following are outcomes from each of the Phase Three teachers:

Dean Field (MatriCal). (1) Determined the skill and knowledge sets most sought after by private industry. (2) Acquired laboratory skills useful to the company. (3) Found real and meaningful experiences and information to bring back into my classroom.

Matt Dykstra (GenPrime). (1) Developed skills in biotechnology (lab skills, organization of projects, research skills, etc) that can be brought into the classroom with confidence. (2) Played a role in the development of new knowledge and products that will be useful to the scientific community and the public. (3) Built a strong connection with area biotech companies and professors to support contacts for wisdom and supplies biotechnology is brought into the classroom.

Ryan Campanella (Signature Genomic Laboratories, LLC). (1) Gained a better understanding of local biotechnology businesses. (2) Became part of 'real research' and increased lab 'awareness.' (Lab awareness meaning to realize what working laboratories do and technologies they use and be able to inform students of what scientists really do when they get a job). (3) Made good contacts with local biotechnology companies and to help develop a positive relationship between the classroom and the science industry.

Dan Dunlop (Hollister Stier Laboratories. (1) Continued to develop an understanding of the skills that are valued/required for students that will potentially be entering the biotech industry. (2) Continued to develop skills as a researcher in the field of biotechnology to effectively transfer this knowledge to students. (3) Increased infusion of the skills, techniques, process / content knowledge, required in the biotech industry into the classroom.

Outreach Activities:

Outreach Activities May 2006-May 2007

? Washington Science Teachers Association Annual Conference. Spokane, WA Presentation of NSF ATE grant objectives and review of summer 2006 Phase One activities. C. Malinak, S. Oliver, D. Lightfoot, D. Schultz. R. Knuth.
? Presentation by Dr. Oliver to a public audience of area educators and industry and business representatives on the importance of math and science education . a description of the NSF ATE grant was incorporated, including the direct and indirect benefits to the community of this specific biotechnology enrichment program.
? C. Malinak and Dr. Oliver were invited to tape the following program for television broadcast throughout the greater Inland Northwest Region: High Growth Careers: Biotechnology/NSF Grant, 'Community Colleges Connections', a 15-minute informational television program about the Community Colleges of Spokane, its programs, services and special initiatives. This program was broadcast many times over a one-month period.
? Presentation on collaborative grant writing by Mr. Malinak and Dr. Oliver to a public audience of educators and researchers. The event 'NSF days at WSU' was sponsored by Washington State University and showcased NSF grant funding opportunities.
? Invited talk by Dr. Oliver to the Washington State Life Science Industry Education Council about the NSF Biotechnology Education Infusion program.
? One-day hands-on biotechnology workshops given to middle and high school students throughout the region by S. Oliver. These workshops introduce students to concepts of biotechnology, provide information on technical careers in biotechnology, and are also a method of recruiting more teachers and counselors for the Yr 2 BEI workshops. To date, Dr. Oliver has presented seven workshops for public and private high school students reaching over 150 students.

Outreach activities May 2007-May 2008

? Invited presentation by C. Malinak and Dr. Oliver at the Regional Grant Writing Workshop sponsored through Washington State University and Spokane Community College entitled Effective Strategies for Writing NSF Grants.
? Washington Science Teachers Association Annual Conference. Spokane, WA. Presentation of NSF ATE grant objectives, review of summer 2007 Phase One activities and hands-on demonstration of a BEI lab project. S. Oliver, and S. Bassett.
? Presentation by Dr. Oliver to the Washington State University Board of Trustees entitled Creating a Foundation of Science and Math for All Students.
? Biotechnology in Your School. Conference workshop. National Science Teachers Association national conference, Boston, MA.
? One-day hands-on biotechnology workshops given to middle and high school students throughout the region by S. Oliver. To date, Dr. Oliver has presented 13 workshops for public and private school high schools reaching over 300 students.

Outreach Activities May 2008 ? May 2009

? 'Creating Community Collaborations' Invited talk. Regional Grant Writing Workshop sponsored through Washington State University and Gonzaga University. Experiences based on the BEI project.
? 'Biotechnology in Your School'. Conference workshop. Advanced Technological Education National Conference, Washington DC.
? 'Science Education in Our Schools'. Science on Tap lecture series coordinated through the Northwest Association of Biomedical Research. Spokane, WA.
? 'GMO's in Your Food'. Conference workshop. Teachers of Teachers of Science Regional Conference, Spokane, WA
? One-day hands-on biotechnology workshops presented to elementary, middle and high school students throughout the region by S. Oliver. During the current reporting period, Dr. Oliver presented 29 biotechnology workshops for public and private school students reaching over 650 students. Students were from a wide variety of learning environments: small rural residential school for Native American students; health career summer camps for Native American students; summer science camp for middle school students; large, mid-size and small urban high needs schools ? both middle and high school students; Skill Center Career and Technical Education students; small, rural high schools with high Native American populations; small, private non-denominational schools, private, Christian schools; small rural alternative high school programs; small, rural charter schools; and a large urban school with home school science program.

Outreach Activities May 2009 ? May 2010

? 'Biotechnology in Your School'. Biotechnology Mentoring/Dissemination National Conference, Carnegie Institution, Washington DC.
? Teachers of Teachers of Science (TOTOS) annual meeting, Presentation of two hands-on workshops for university science education faculty from throughout the Pacific NW and Canada.
? 'Science Education in our Schools'. Science on Tap lecture series coordinated through the Northwest Association of Biomedical Research, Sandpoint, ID.
? 'Biotechnology Education, Spokane Skill Center Administrative Council Meeting (Superintendents of the 11 participating Skill Center school districts). Presented future potential for developing a biotechnology program at the Spokane Skill Center, including overview and impact of the BEI project.
? Career Day, Cheney HS. Representing WSU for science career pathways. Made panel presentations to all 9th grade students at CHS, emphasizing the importance of biotechnology career pathways.
? 'Creating a Foundation in Math and Science for All Students'. Invited Talk. Rotary Club North, Spokane, WA.
? Numerous day-long biotechnology workshops for classrooms of public, private and alternative school students from throughout the NW region. Dr. Oliver taught 30 workshops reaching nearly 700 students.

Journal Publications

Books or Other One-time Publications

Web/Internet Site

URL(s):

http://spokane.wsu.edu/researchoutreach/CityLab/biotech.html
Description:

Other Specific Products

Product Type:

Teaching aids

Product Description:

A BEI Guide was created for as a resource for BEI teachers and counselors. The 90-page BEI Guide covers a wide variety of resource material of importance to educators who are infusing biotechnology curriculum and labs into their classrooms including: career information; funding, equipment and educational resources; professional opportunities; ideas for online student activities; biotechnology safety resources; math, ethics and genetics resources; and downloadable worksheets and activities from government websites.

Sharing Information:

All BEI teachers and counselors have received the BEI Guide in a CD format. The BEI Guide is also posted on the WSU Spokane Citylab BEI website and will be updated on a regular basis by the BEI staff. Teachers and counselors will be encouraged to offer suggestions for the BEI Guide including labs, curricular materials, and online resources. The availability of the BEI Guide on the WSUS CityLab website will be introduced to regional teachers and counselors via postings on the Washington Science Teachers Association listserve; via links to Bio-Link and ATE Central; through Spokane Community College Department of Biology; and through presentations at future teacher conferences (eg WSTA, NSTA, NABT). Dr. Oliver will also give the BEI CD Guide to all teachers who bring their students to WSU Spokane CityLab.

Contributions

Contributions within Discipline:

Contributions within Discipline
Based on the goals of the BEI project, the cumulative findings demonstrate that the BEI STEM professional development model is highly successful for increasing teacher, counselor and student knowledge about the biotechnology industry; and for increasing the use of biotechnology lab and inquiry activities in the classroom. Phase One, Two and Three teachers gained content knowledge (CK) about biotechnology and the educational and career options available to students. They also gained valuable biotechnology laboratory skills sets and inquiry-based pedagogical content knowledge (PCK) and were able to infuse curricula and biotechnology lab activities into their classrooms. Three primary areas of interest that will contribute to the base of knowledge, theory and research and pedagogical methods in the field of STEM education were identified during the course of the BEI project: (1) The different impact of the Phase One, Two and Three professional development models; (2) the impact of self efficacy on teacher outcomes; and (3) the impact of different school environments on teacher, counselor and student outcomes.
(1) Impact of the Phase One, Two and Three professional development models
It was of interest to BEI project staff to determine whether or not enriching the Phase One teacher experiences with participation in five-week Phase Two biotechnology research experiences and five-week Phase Three industry internships would enhance classroom teaching, thus optimizing student learning. Teachers in both Phase Two and Phase Three self-selected and represented veteran teachers. Our findings, based on 69 Phase One teachers and 19 Phase One counselors, 14 Phase Two teachers and 27 Phase Two high school students, and 4 Phase Three teachers, indicate there were no demonstrable changes in student outcomes with additional professional development training. Although significant self-reported improvements in teacher knowledge, skills and interest in lab-based inquiry experiences were reported over the three phases, especially following the five week research experience, very few teachers were able to consistently include inquiry-based activities in their curriculum with little change in student interest in science or science careers noted. Barriers to translation of inquiry theory and skills into the classroom included time constraints due to district curricular mandates (greatest barrier); time constraints due to administrative duties; and lack of self-confidence to direct more open-ended student research projects. This finding is of significant interest to the STEM education field since inquiry-based teaching is strongly supported by the American Association for the Advancement of Science1 and the National Research Council 2,3 as a strategy to develop greater student understanding of science through active engagement in the scientific process. However, studies show most K-12 teachers have little experience with inquiry training4; and evidence indicates that those who do receive training either through summer research experiences (e.g. NSF???s RET program) or other professional development programs have difficulties effectively transferring this training into the school classroom 4,5. The following are conclusions based on our quantitative findings:
--The intensity of professional development does not alone translate into improved student performance. It is a necessary, but not sufficient factor.
--Teachers that have a plan and the flexibility to focus their entire course on student research will see the most gains in student performance. While Phase Two would probably be a useful experience, a teacher that has some research experience and goes through a Phase One-like training can make significant headway in student performance.

--Implementing 1, 2 or 3 inquiry units or labs is probably too small an intervention in the context of a semester-long or year-long course to make a difference on whole-class mean performance scores.
--Each Phase does have a significant learning impact on teacher and counselor participants, but the context in which teachers and counselors work, coupled with their specific plans and self-efficacy, will determine how it translates into pedagogy and ultimately to student performance.

The above conclusions are fully supported by the following brief description of one of our teachers in terms of student gains in interest in science and biotechnology tasks, perception of classroom-based inquiry, and interest in STEM careers. This teacher is unique as compared to the majority of her colleagues in that her class was fully dedicated to biotechnology research. Over three years, the percent of students in this class interested in STEM careers jumped from about 40% to 64% pre to post. Of these, about 60% were interested in biology at the time of the pre as compared to 80% on the post. Only 27% agreed that science was exciting on the pre as compared to 69% on the post; solving science problems is fun (26% to 53%); and I like science more than most other subjects (20% to 69%). Only 9% of students indicated on the pre they enjoyed talking to others about science as compared to 45% on the post. Similar results were found for the biotechnology tasks scale. Only 14% of students indicated an interest in designing and performing biotech experiments on the pre as compared to 38% on the post. On the post-survey, 47% reported an interest in devising new ways to use bacteria and other microorganisms, up from 17% on the pre. Changes in perception about classroom inquiry were particularly large and positive.

These findings, combined with results of teacher interviews, have directed us to propose a study of professional development training in inquiry pedagogy supported by in-school Research Courses to provide the time, resources and mentored support to sustain in-depth comprehensive inquiry-based learning experiences for BOTH teachers and students. Professional development inquiry training supported through research courses will result in improved student outcomes including improvements in standardized test scores; increased STEM educational and career aspirations; and a new generation of students with the knowledge and understanding of STEM to make informed personal choices, to be educated voters, and to thrive in the increasingly technological global marketplace.
(2) Impact of self-efficacy and teacher efficacy on teacher outcomes
Although most BEI teachers did not incorporate more advanced biotechnology laboratory exercises or authentic research experiences, the BEI staff identified a cadre of teacher leaders who did provide these activities. The defining attribute of all teachers in this category was their self-confidence and belief in their abilities to accomplish a task (self efficacy)6 and impact student outcomes (teacher efficacy)6,7 even though most did not participate in Phases Two or Three. In other words, if a teacher believes he/she can perform tasks well in a given area (self efficacy) and also believes they can affect student engagement and learning (teacher efficacy), this will lead to interest in pursuing a particular content area or laboratory activity, even with limited CK or PCK. Teacher efficacy will, in turn, positively impact student interest, outcomes, and educational and career intentions. This was evident in our teacher leaders who represented a wide range of teaching experience (some veteran teachers, some early in their teaching careers), school environments (large urban to small private) and grade level (middle school vs high school).
Interestingly, many of the teachers identified as having high self-efficacy and teacher efficacy were middle school teachers. This group accessed, at high rates, most of the resources offered through the BEI program (lab materials, equipment, field trips, conferences, WSU Spokane CityLab and BEI mentoring). All these teachers had their students conduct several biotechnology lab activities, a considerable challenge in the middle school setting. Unfortunately, none were identified for the Phase Two research experience based on the requirement to teach at the high school level. Interestingly, during the BEI grant period, one of the middle school teacher leaders was accepted for a three-year research internship at the Pacific Northwest National Laboratories (PNNL) where she will participate in two-month bench research experiences and present her findings at annual national conferences. Based on our experiences with the middle school teachers, we would now recommend they be considered for any bench or industry research experience with a high likelihood that the resulting gains in CK and PCK will be translated into their classrooms.
The impact of self-efficacy is also supported through self-assessment scores related to inquiry and biotech skills from Phase One teachers during their Week Two laboratory experiences. It was found that teachers who did NOT implement curriculum or lab activities in their classrooms (Level 0) tended to have lower pre and post-Week Two self-assessment means. In fact, their Week Two post mean was about the same as the Week Two pre surveys for both the Level 1 (moderate) and Level 2 (high) implementers. Additionally, the Level 2 implementers had a slightly higher post mean score than the Level 1 implementers. Of importance to the field of STEM education and professional development educators is that self-assessments could be a useful guide to predict teacher self-efficacy requiring increased levels of support by professional development educators, especially for Level 0 teachers.
(3) Impact of the school environment on teacher outcomes
Teachers and counselors from a total of forty-five schools from Washington, Oregon, Idaho and Montana participated in the BEI program. A wide variety of middle schools and high schools were represented including: large, mid-size and small urban public schools (many from high needs districts serving underrepresented students); small rural schools with high Native American student enrollment; small, private non-denominational schools; small, private Christian schools; alternative schools for at-risk students; and alternative programs for home school students. Of interest was the high BEI activity rate of teachers and counselors from the smallest schools including the small, private Christian schools versus public school teachers, especially those from larger urban schools, who were unable to offer more than one or two basic biotechnology labs for their students. Of the 45 schools, we could class 11 as being very small (either rural, private or alternative). Teachers from nine of these schools accessed all or most of the BEI resources (equipment, lab materials, BioRad kits, funds for field trips and/or

conferences, attendance at E.Daugherty???s biotechnology workshop, receiving minigrant funds). All but one received minigrants, increasing the likelihood they will continue to offer these biotechnology experiences in their classrooms. Two teachers offered advanced non-kit biotechnology inquiry labs for their students (e.g. inquiry PCR labs) while over half presented advanced BioRad kit labs for their students (e.g. the GMO lab). The two main reasons these teachers had the flexibility to incorporate multiple labs and have the instructional time to prepare students for these hands-on experiences were (1) small class sizes and (2) not having to adhere to a highly structured curriculum designed to prepare students for standardized tests.
Based on these findings, we recommend to STEM educators and providers of professional development programs that extra attention and time be provided during training to allow public school teachers to develop clear ways to infuse PD materials into the rigorous and structured science curriculum. Again, recommendations from public school teachers support the development of SEPARATE RESEARCH COURSES to allow teachers the time and freedom to offer in-depth and long-term inquiry research experiences for their students. From these courses, the students will have the time not only to learn about the nature of science and STEM content knowledge, but they will also have the time to learn practical lab skills, soft skills, regulatory knowledge, and current and emerging STEM career pathway options (e.g. industrial, environmental, food and agriculture, health and medical).
Another finding of importance to STEM educators and providers of professional development programs is the importance of providing equipment and lab materials to all teachers. Only seven of the 45 schools had biotechnology equipment. Without the support of the Equipment Loan Program, teachers would have been forced to only offer their students internet or paper exercises, a poor substitute for direct hands-on laboratory experiences. Five additional school were able to purchase some biotechnology equipment through the minigrant program, but it will be important to continue to provide equipment and lab materials to encourage continuation of BEI activities in all schools.

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Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Human Resources Development

(1) Providing opportunities for research, teaching and mentoring in science and engineering areas and providing exposure to science and technology for pre-college teachers, young people and other non-scientist members of the public.
The Biotechnology Education Infusion (BEI) Program was designed to provide teaching, research experiences and mentoring in biotechnology to middle and high school science teachers and school counselors. The goal was to increase the content knowledge and pedagogical content knowledge of teachers and counselors for them to be able to increase student understanding of, and interest in, careers in biotechnology through improved curricula, career information and hands-on laboratory experiences. This goal was largely achieved through the following strategies:
Strategy 1: Give participants information on biotechnology technician careers, educational pathways, and active learning strategies for translation into the classroom.
Strategy 2: Give teachers guided biotechnology laboratory projects to translate into student-centered laboratory investigations.
??? Phase One, Two-week BEI Institute (Years One, Two and Three): Train teachers in skills necessary to conduct short-term laboratory-based biotechnology projects for the classroom.
??? Phase Two, Six-week Biotechnology Lab Experiences (Years Two and Three): Provide teacher-student teams with in-depth mentored biotechnology lab experiences using authentic industry research projects.
??? Phase Three, Six-week Industry Internships (Year Three): Provide teachers with industry internships to improve translation of their biotechnology laboratory experiences into the classroom, to develop long-term collaborations with biotechnology companies, and to form a regional network of experienced biotechnology educators.
Science teacher outcomes included the following: (1) gained a familiarity with careers in biotechnology and the educational pathways to guide students into biotechnology: (2) gained a clear understanding of biotechnology lab skills and the biotechnician work environment, (3) assisted in the development of a BEI Resource Guide including instructional materials, laboratory investigations and career advising materials to infuse into the classroom; (4) implemented biotechnology curricular materials and lab experiences in their classrooms; and (5) incorporated

inquiry-based, active learning strategies in the classroom. Career counselor outcomes included the following: (1) gained an understanding of technician careers and skills in biotechnology and of educational pathways necessary for those jobs; (2) included this information in new career counseling materials, and(3) showed a more positive attitude about science, math and biotechnology careers. Middle and high school student outcomes included the following: (1) gained a better understanding of biotechnology career opportunities and the specific educational pathways leading to them, (2) gained more experience with hands-on biotechnology labs and inquiry-related activities in the classroom.

(2) Improving the performance, skills, or attitudes of members of underrepresented groups that will improve their access to or retention in research and teaching careers:
Teachers and counselors from a total of forty-five schools from Washington, Oregon, Idaho and Montana participated in the BEI program. A wide variety of middle schools and high schools were represented including: large, mid-size and small urban public schools (many from high needs districts serving underrepresented students); small rural schools with high Native American student enrollment; small, private non-denominational schools; small, private Christian schools; alternative schools for at-risk students; and alternative programs for home school students. Of the 45 schools, 11 were identified as very small (private, rural or alternative) with two of these schools having high Native American student populations (44% and 72%). Although much of the literature to date has focused on students of color and young women as being underrepresented in STEM fields, new reports are focusing on the impact of poverty as an indicator of failure to pursue and achieve in these fields.1 With these findings in mind, the BEI project also provided much-needed training and resources to 34 public schools who all serve students of poverty and offered these students enriched classroom and lab experiences and a better vision of possible career options in STEM fields. In several of the larger school districts with high levels of poverty, it was fortunate that both middle and high school teachers participated in the BEI program (n=4 schools). In coming years, this will afford these students repeated exposure to curriculum and laboratory activities in biotechnology leading to improved content knowledge and science skills, and a better understanding of STEM education and career options.

(3) Developing and disseminating new educational materials or providing scholarships:
As noted above, the BEI program developed and provided career information, classroom curriculum and laboratory activities for middle and high school teachers and counselors. Much of this information and many of the lab activities have been incorporated into a BEI Resource Guide that can be found at http://spokane.wsu.edu/researchoutreach/CityLab/biotech.html. Additional labs and teaching resources can be found on the WSU Spokane CityLab BEI website.

1. Kohlhaas, K., Lin,. H. and Chu, K. Disaggregated Outcomes of Gender, Ethnicity, and Poverty on Fifth Grade Science Performance. Research in Middle Level Education Online. 33, 1-12 (http://www.nmsa.org/portals/0/pdf/publications/RMLE/rmle_vol33_no7.pdf

Contributions to Resources for Research and Education:

The BEI project purchased equipment for two biotechnology kits that are provided to BEI teachers at no cost. This equipment will also be provided to other regional teachers interested in implementing biotechnology laboratory experiences for their students. The following are descriptions of the Basic Biotechnology Kit and the Advanced Biotechnology Kit:

Basic Kit (sufficient for 24 students; teams of 3 students))

4 power supplies
8 gel boxes
1 mini-fuge
16 pipettes (8, p20; 8, p200)
1 light box

Advanced Kit

1 power supply
1 Owl A1 gel box
Thermocycler
Micro-fuge
8 pipettes (2)p2, (4)p20, (2)p200
1 vortex
1 mini-fuge

Contributions Beyond Science and Engineering:

Conference Proceedings

Categories for which nothing is reported:

Any Journal
Any Book
Contributions: To Any Other Disciplines
Contributions: To Any Beyond Science and Engineering
Any Conference

BEI Evaluation Findings

for Dr. Sylvia Oliver, Washington State University

National Science Foundation

by

Knuth Research Inc.

August 30, 2010

Introduction

The goal of the BEI evaluation was to (1) provide formative data to help the project team continually improve products and services offered to teachers and students, and (2) determine the efficacy of three levels of professional development in terms of their impact on teacher and student outcomes. The original student outcome target was to increase the number of students that enrolled in the Biotechnology Program at Spokane Community College However, that program was abolished during Year One of the project and so this outcome became unattainable and thus not measurable. Therefore, the project team made a decision to focus on student interest in science, interest in biotechnology tasks, and predicted postsecondary area of study. This report focuses on findings of the project as they related to student and teacher outcomes.

BEI offered 3 Phase 1 summer institutes, each providing training to teachers and counselors for one week followed by an additional one-week intensive training for teachers. Week Two focused on inquiry-based instruction and biotechnology lab skills and activities.

A small number of teachers from cohorts 1 and 2 were selected to participate in Phase 2 research experiences during the second and third summers. The target was for eight teachers each summer who would select two students from their high schools to work with them in a lab with a researcher mentor.

Phase 3 engaged four teachers in research externships with local biotechnology companies.

Findings

Based on data collected at the student, teacher and counselor levels, the evaluation notes the following findings as the most important lessons learned from the approach of this project. Specific data results are given in the following sections of this document.

- The BEI project provided high quality, intensive training and support to teachers and counselors in each of the three Phases. In addition, Phase 2 provided high quality research opportunities for high school students.

- Participating teachers continued to implement facets of the program (e.g., labs and activities) and relied on technical and materials support from the project leaders throughout the four years of the grant.

- The intensity of professional development (i.e., whether teachers participate in Phases 1, 2, and/or 3) does not alone translate into improved student performance in the classroom. High quality training and support is a necessary, but not sufficient, factor to change student outcomes.

- Participating in higher levels of the program (e.g., Phases 2 and 3) does seem to increase the chances that a teacher will engage in significant implementation of project concepts and strategies in the classroom.

- Teachers that have a vision and the flexibility to focus their entire course on student research will see the most gains in student performance. While Phase 2 would probably be a useful experience, a teacher that has some research experience and participates in a Phase 1-like training can make significant headway in student performance gains.

- Implementing 1, 2 or 3 inquiry units or labs is probably too small of an intervention in the context of a semester-long or year-long course to make a difference on whole-class mean performance scores.

- Each phase does have a significant learning impact on teacher and counselor participants, but the context in which the teachers work, coupled with their specific plans and self-efficacy, will determine how it translates into pedagogy and ultimately to student performance.

- As measured by researcher and teacher observational assessments, teachers and students, respectively, made significant gains in their knowledge and skills related to biotech research.

- Based on follow-up communications with participants, about 10% of the teachers and counselors did nothing in terms of implementation after their participation in BEI; about half implemented to a moderate level; and about 40% indicated they had significantly implemented biotech into their teaching or counseling duties.

- Teachers who did NOT implement tended to have lower pre and post-Phase One Week Two self-assessment scores(which dealt with inquiry and biotech skills) than those who implemented curriculum and/or lab activities in their classrooms. Self-assessments could therefore be a useful guide to predict teacher self-efficacy requiring increased levels of support by professional development educators for this identified group.

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STUDENT RESULTS: Phases One and Two

Student Impact - Phase 1

A survey designed to measure interest in science and biotechnology was developed by the project team during the summer of 2006. The survey collected the following demographic information: grade, age, gender, race. Students were also asked to provide an arbitrary ID number made up by the teacher, school, teacher, and course name. Students were also asked to predict the total number of years of science that they would take in high school and to name the subject area(s) they were planning to study if they went to high school.

The survey contained three Likert scales: science interest, biotechnology task interest, and classroom inquiry. The science interest standards were modeled from existing interest surveys. The interest in performing biotechnology tasks were derived from biotech standards. The classroom inquiry items were developed by identifying the key components of inquiry-based instruction as it relates to a science classroom. The items for each scale are given below.

Science Interest Items

1. I think science is exciting.
2. Solving science problems is fun.
3. I like science better than I do most other subjects.
4. I have a real desire to learn science.
5. Science is useful for solving problems in my everyday life.
6. Learning science will improve my career chances.
7. I have a good feeling toward science.
8. I enjoy talking to people about science.
9. I like writing about science.
10. I like to read books, magazines and Web sites about science.

Biotechnology Task Interest Items

1. Create new drugs to treat diseases.
2. Discover cures for diseases like cancer.
3. Develop methods to detect bio-warfare agents such as anthrax.
4. Design a way to check for food poisons.
5. Alter DNA to change the characteristics of plants and animals.
6. Devise new ways to use bacteria and other microorganisms.
7. Use computers to study the genetic code of living things.
8. Invent substances used to make new products.
9. Experiment with new ways to improve foods.
10. Use clues from crime scenes to solve murder mysteries.
11. Perform genetic tests to trace the evolution of plants and animals.
12. Work with test tubes, pipettes, beakers & other equipment in a laboratory.

13. Prepare biological materials for use in research.
14. Design and perform biotech experiments in a laboratory.
15. Maintain and troubleshoot equipment used in making products.

Classroom Inquiry Items ("In my science classroom...")

1. I get to do real-life research.
2. I usually get to come up with the research questions I want to answer.
3. I get to decide how to go about answering my research questions.
4. I get to decide what data I need to answer my research questions.
5. I get to share the answers to my research questions with my parents, community members, on the Internet, or with other people outside this classroom.
6. I have investigated at least one research question about DNA, genes, or another biotechnology topic in this class.

Chronbach's alpha (reliability) that measures internal consistency for each scale is given in the table below. All values are high and suggest that the items for each scale were measuring the same construct.

TABLE 1: Chronbach's Alph (Reliability) for Survey Scales

Scale	Cronbach's Alpha	N of Items
Science Interest	.912	10
Biotechnology Task Interest	.930	15
Classroom Inquiry	.800	6

After each teacher attended the summer institute, he or she was encouraged to schedule a date for both the pre and post-surveys. In most classrooms the surveys were administered online. Teachers were asked to continue offering the surveys each following year of the project. Over the course of the project, 4680 pre and 3705 post surveys were submitted by students. Student survey data came from 61 teachers in 39 schools in WA, MT, ID and OR.

For the analysis, only data from teachers that had both pre and post surveys submitted were used so results were not diluted or exaggerated by classrooms with only one survey administration. In addition, only grades 7 through 12 were utilized as the student survey was thought to be inappropriate for students in elementary grades. Data came from students distributed among 46 teachers in 32 schools that had both pre and post-surveys. Total surveys analyzed: 7451 (4047 pre, 3404 post). It was hoped that surveys from each student could be matched on ID number so that pre and post-surveys could be compared at the student level. However, the ID assignment tended to be harder to implement than anticipated (students forgetting their ID) and thus the analysis of surveys was done at the classroom level. For Year One there were about 92% as many post-surveys as pre-surveys submitted. For Years Two and Three, the rates were 90% and 78%, respectively.

TABLE 2: Number of Surveys Each Year, Pre and Post

		Pre or Post Survey.		
		Pre	Post	Total
Year survey was taken.	2006-2007	700	646	1346
	2007-2008	1301	1171	2472
	2008-2009	2046	1587	3633
Total		4047	3404	7451

There tended to be more females in the classes taught by participating teachers than males. This was especially true in Years One and Two of the project where the difference was about 5 percentage points higher for females. The difference in Year Three was about 2 percentage points favoring females.

TABLE 3: Breakdown of Surveys by Gender

			Pre or Post Survey.		
Year survey was taken.			Pre	Post	Total
2006-2007	Are you a female or a male?	Female	53.5%	51.4%	52.5%
		Male	46.5%	48.6%	47.5%
	Total		100.0%	100.0%	100.0%
2007-2008	Are you a female or a male?	Female	52.4%	53.2%	52.8%
		Male	47.6%	46.8%	47.2%
	Total		100.0%	100.0%	100.0%
2008-2009	Are you a female or a male?	Female	50.1%	52.2%	51.1%
		Male	49.9%	47.8%	48.9%
	Total		100.0%	100.0%	100.0%

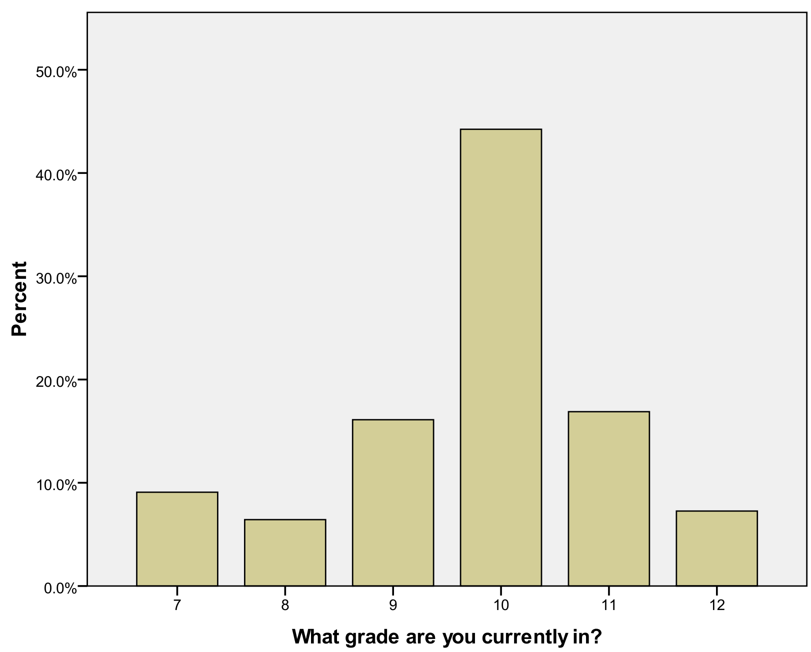
Student-reported ethnicity was fairly consistent across all three years with about 70% selecting white, around 6% not answering, 5% selecting other, and the remainder distributed fairly evenly among the remaining 5 classifications.

TABLE 4: Student Ethnicity

		Pre or Post Survey.		Total
		Pre	Post	
What is your race?	African American	3.7%	4.8%	4.2%
	Asian	4.2%	4.7%	4.4%
	Hispanic	3.8%	4.2%	3.9%
	Native American	2.8%	2.7%	2.7%
	Pacific Islander	2.7%	3.1%	2.9%
	White	71.9%	70.3%	71.2%
	Other	5.4%	4.6%	5.1%
	Do Not Wish to Answer	5.6%	5.6%	5.6%
Total		100.0%	100.0%	100.0%

The grade level which included the largest number of students was grade 10 (44%). Grades 9 and 11 had nearly the same percentage of students (around 16%). Nine percent of total surveys were submitted by 7th graders, while 8th and 12th grade represented about 6% and 7% of all surveys.

CHART 1: Grade Level Distribution



The mean age of students submitting the pre-survey was 15.0 (+/-1.3) while on the post was slightly higher (15.5 +/- 1.3). This is an expected result since student ages would naturally be somewhat higher at the end of the semester or school year when the post-survey is administered.

The majority of students (55.8%) indicated they will have taken four years of high school science while about 30% predicted three years. A larger percentage of females than males (58.8% versus 52.5%, respectively) predicted four year sof high school science. Only slight difference between pre and post were found for male students: slightly more (increase of 2 percentage points) indicated they would take three as compared to two years of science in high school.

TABLE 5: Predicted Number of Years of High School Science

Are you a female or a male?			Pre or Post Survey. Pre	Post	Total
Female	How many years of science do you think you will have taken in high school by the time you graduate?	1	1.3%	1.7%	1.5%
		2	10.7%	10.4%	10.5%
		3	29.2%	29.2%	29.2%
		4	58.9%	58.7%	58.8%
	Total		100.0%	100.0%	100.0%
Male	How many years of science do you think you will have taken in high school by the time you graduate?	1	2.5%	2.6%	2.5%
		2	14.5%	12.7%	13.7%
		3	30.4%	32.3%	31.3%
		4	52.6%	52.4%	52.5%
	Total		100.0%	100.0%	100.0%

TABLE 6: Percent of Students Interested in STEM Career by Gender

Are you a female or a male?			Pre or Post Survey. Pre	Post	Total
Female	Interested in STEM Career	Not Interested	48.1%	47.6%	47.9%
		Interested	51.9%	52.4%	52.1%
	Total		100.0%	100.0%	100.0%
Male	Interested in STEM Career	Not Interested	45.0%	44.9%	45.0%
		Interested	55.0%	55.1%	55.0%
	Total		100.0%	100.0%	100.0%

Students were asked, ' If you go to college someday, what subject do you think you would like to study?.' Results were classified into STEM and non-STEM careers based on the subject or content mentioned. The overall percentages of students interested in pursuing a STEM career remained constant from pre to post survey with roughly 53% indicating an interest in STEM. A higher percentage of males as compared to females indicated an interest in STEM careers.

The STEM career interest breakdown by ethic category presented differences between groups. The results should be interpreted carefully, however, since each group other than white only made up a small percentage of the total surveys submitted. The results should be explored further.

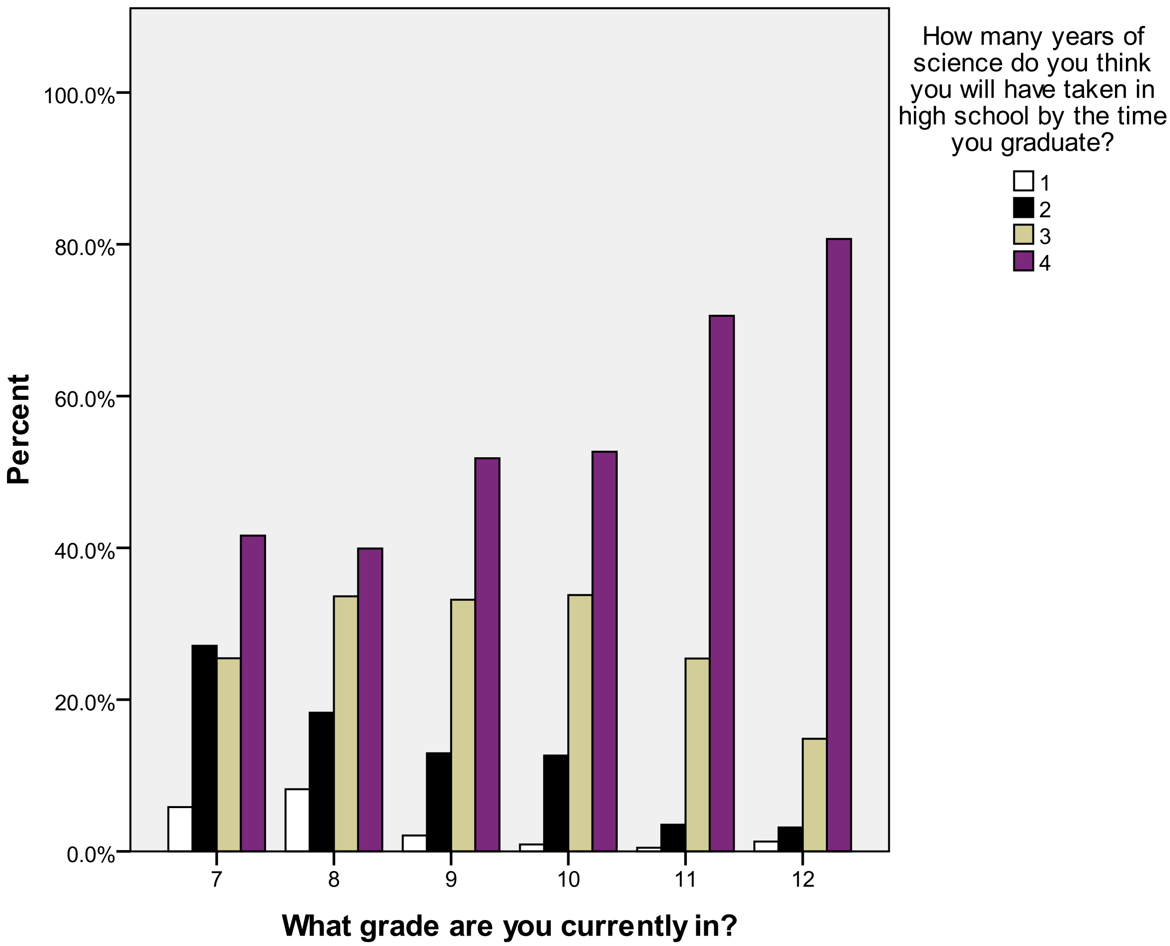
TABLE 7: Interest in STEM Career by Ethnic Category

% within Pre or Post Survey.

What is your race?			Pre or Post Survey. Pre	Post	Total
African American	Interested in STEM Career	Not Interested	50.7%	49.7%	50.2%
		Interested	49.3%	50.3%	49.8%
	Total		100.0%	100.0%	100.0%
Asian	Interested in STEM Career	Not Interested	35.5%	39.1%	37.3%
		Interested	64.5%	60.9%	62.7%
	Total		100.0%	100.0%	100.0%
Hispanic	Interested in STEM Career	Not Interested	51.8%	56.7%	54.2%
		Interested	48.2%	43.3%	45.8%
	Total		100.0%	100.0%	100.0%
Native American	Interested in STEM Career	Not Interested	47.6%	55.4%	51.1%
		Interested	52.4%	44.6%	48.9%
	Total		100.0%	100.0%	100.0%
Pacific Islander	Interested in STEM Career	Not Interested	31.1%	31.6%	31.3%
		Interested	68.9%	68.4%	68.7%
	Total		100.0%	100.0%	100.0%
White	Interested in STEM Career	Not Interested	46.7%	46.4%	46.6%
		Interested	53.3%	53.6%	53.4%
	Total		100.0%	100.0%	100.0%
Other	Interested in STEM Career	Not Interested	49.0%	48.3%	48.7%
		Interested	51.0%	51.7%	51.3%
	Total		100.0%	100.0%	100.0%
Do Not Wish to Answer	Interested in STEM Career	Not Interested	53.3%	43.9%	48.9%
		Interested	46.7%	56.1%	51.1%
	Total		100.0%	100.0%	100.0%

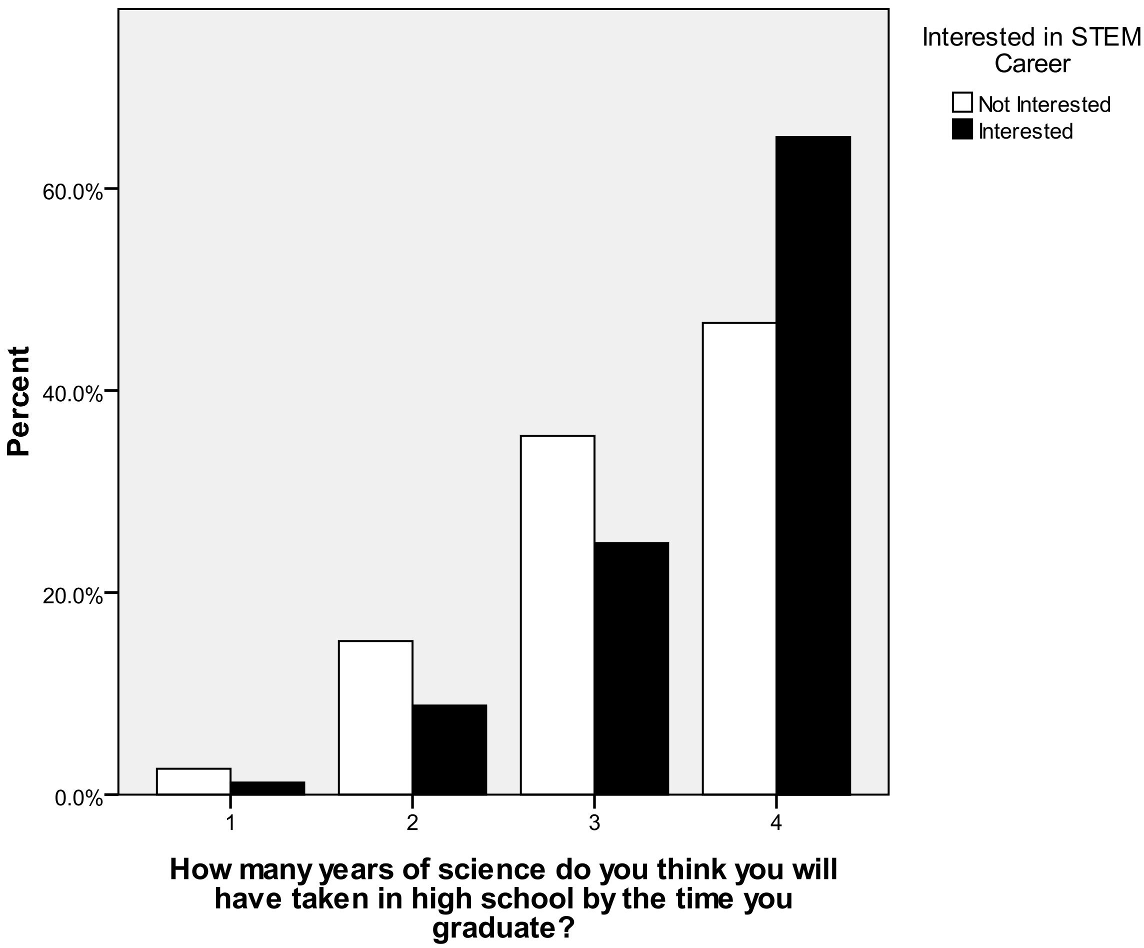
The percent of students anticipating they would take four years of science in high school increased with grade level. As expected, the numbers are highest for grade 12 since they were in a science class when the survey was administered and most likely in an advanced science class with most of the students have taken science three years prior. It is interesting to note there is an increase from junior high to high school (grades 9 and 10) which suggests that a higher proportion of students are planning to take four years of science. By grade 11 there appears to be a significant increased commitment to four years of high school science.

CHART 2: Years of Expected HS Science by Grade Level



As expected, the more high school science that was predicted by students ,the more students reported an interest in a STEM career. The chart below shows that over two-thirds of those students that are taking four years of high school science listed a STEM career as an intended area of study in post-secondary education. In contrast, for those who anticipate taking only the minimum number of years of high school science classes, the percentage interested in STEM is less than a tenth.

CHART 3: Years of Expected HS Science and Interest in STEM



The more years of high school science that students predicted taking, the more likely they were to express an interest in a STEM career. For those that predicted one year of high school science, the proportion that expressed and interest in STEM actually decreased by about 9 percentage points from pre to post-survey. A similar, though smaller decrease was also found for students predicting two years of science. For those that predicted four years of high school science, the proportion that mentioned an interest in STEM jumped from 60.2% to 63.2%. Twice as many students in the 'four years of high school science' category reported an interest in STEM as did those in the 'one year' category.

TABLE 8: Interest in STEM Career by Pre/Post Survey by Years Predicted HS Science

How many years of science do you think you will have taken in high school by the time you graduate?			Pre or Post Survey.		
			Pre	Post	Total
1	Interested in STEM Career	Not Interested	60.9%	69.4%	65.1%
		Interested	39.1%	30.6%	34.9%
	Total		100.0%	100.0%	100.0%
2	Interested in STEM Career	Not Interested	56.8%	63.9%	60.0%
		Interested	43.2%	36.1%	40.0%
	Total		100.0%	100.0%	100.0%
3	Interested in STEM Career	Not Interested	54.7%	56.2%	55.4%
		Interested	45.3%	43.8%	44.6%
	Total		100.0%	100.0%	100.0%
4	Interested in STEM Career	Not Interested	39.8%	36.8%	38.4%
		Interested	60.2%	63.2%	61.6%
	Total		100.0%	100.0%	100.0%

There were noticeable changes from pre to post in terms of STEM interest when disaggregated by grade level. Increased percentages from pre to post interest in STEM were found for students in grades 7, 9, and 12, while slight decreases were found for students in grades 8, 10, and 11. Positive differences were greatest for 7th graders (increase of about 10% points) and moderate for 9th and 10th grade (3 and 4 percentage points, respectively).

TABLE 9: Interest in STEM on Pre/Post by Grade Level

			What grade are you currently in?						
Pre or Post Survey.			7	8	9	10	11	12	Total
Pre	Interested in STEM Career	Not Interested	51.3%	44.7%	48.1%	49.9%	39.0%	39.1%	46.6%
		Interested	**48.7%**	55.3%	51.9%	50.1%	61.0%	**60.9%**	53.4%
	Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Post	Interested in STEM Career	Not Interested	40.6%	46.2%	45.1%	51.0%	43.1%	35.5%	46.5%
		Interested	**59.4%**	53.8%	54.9%	49.0%	56.9%	**64.5%**	53.5%
	Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The increased interest in STEM was accounted for proportionally by more females than by males, especially at grade 7 in which there was a jump of 20 percentage points for females as compared to 1 percentage point for males. It should be remembered, however, that students in grades 7 and 12 make up about 16% of all surveys.

TABLE 10: Interest in STEM on Pre/Post by Grade Level and Gender

Are you a female or a male?	Pre or Post Survey.			What grade are you currently in? 7	8	9	10	11	12	Total
Female	Pre	Interested in STEM Career	Not Interested	59.1%	46.0%	52.5%	49.7%	40.7%	40.7%	48.1%
			Interested	**40.9%**	54.0%	47.5%	50.3%	59.3%	**59.3%**	51.9%
		Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Post	Interested in STEM Career	Not Interested	38.8%	44.4%	50.0%	52.2%	46.3%	33.0%	47.6%
			Interested	**61.2%**	55.6%	50.0%	47.8%	53.7%	**67.0%**	52.4%
		Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Male	Pre	Interested in STEM Career	Not Interested	44.0%	43.1%	44.3%	49.7%	36.8%	37.3%	45.0%
			Interested	56.0%	56.9%	55.7%	50.3%	63.2%	62.7%	55.0%
		Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Post	Interested in STEM Career	Not Interested	42.6%	48.0%	40.4%	49.6%	38.1%	39.0%	44.9%
			Interested	57.4%	52.0%	59.6%	50.4%	61.9%	61.0%	55.1%
		Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

In addition to items related to interest in science courses and STEM careers, three Likert scales were developed: *Science Interest*, *Biotechnology Task Interest*, and *Classroom Inquiry*. Means for the Likert scales were calculated by assigning numerical values to each response choice:

1: Disagree Strongly
2: Disagree
3: Neutral
4: Agree
5: Agree Strongly

For the *Science Interest* scale, rank order was calculated by ordering from highest to lowest mean for each item. The table below presents the means and rank orders for pre and post-student surveys. These results were computed from all pre and post -surveys before disaggregation. From pre to post there were only negligible rank order differences for the 10 science interest items. At the top of the list were items dealing with the importance of science, feelings toward science, and utility of science. At the bottom of the rank order were students' (lack of) interest in writing, reading, and talking about science.

In general, there were small, yet positive, changes from pre to post on most items. The item with the largest increase from pre to post (albeit small) was the students' enjoyment with respect to talking about science. In general, on the post survey, students were somewhat positive about seven of the items related to science interest and ambivalent about the rest.

TABLE 11: Student Survey Overall Means and Rank Order (Pre and Post) Science Interest Items

Item	Pre Mean	Pre Rank	Pre N	Pre STD	Post Mean	Post Rank	Post N	Post STD
Learning science will improve my career chances.	3.81	1	4018	1.06	3.82	1	3387	1.06
I think science is exciting.	3.51	2	4035	1.04	3.58	2	3398	1.02
I have a good feeling toward science.	3.40	3	4017	1.06	3.44	3	3384	1.06
Science is useful for solving problems in my everyday life.	3.22	4	4017	1.06	3.21	5	3391	1.07
I have a real desire to learn science.	3.20	5	4012	1.12	3.21	4	3385	1.13
I like science better than I do most other subjects.	2.89	6	4023	1.24	2.98	6	3381	1.25
Solving science problems is fun.	2.87	7	4025	1.11	2.91	7	3384	1.13
I enjoy talking to people about science.	2.70	8	4013	1.10	2.84	8	3382	1.11
I like to read books, magazines and Web sites about science.	2.56	9	4018	1.13	2.63	9	3376	1.15
I like writing about science.	2.35	10	4011	.99	2.37	10	3386	1.01

Another way to look at these data is to present the proportion of students that agreed or strongly agreed with each statement. Again, slight increases from pre to post-survey are found on nine of the ten items. Over 70% of students think science is important for their careers, and over 60% think science is exciting. In contrast, very few students like writing about science. While still low, a gain was made in the percent of students who were positive about reading science-related materials and talking about science.

TABLE 12: Percent of Students that Agree/Agree Strongly - Science Interest Items

Item	Pre	Post
I think science is exciting.	61.5%	63.8%
Solving science problems is fun.	34.2%	35.6%
I like science better than I do most other subjects.	39.1%	41.9%
I have a real desire to learn science.	44.8%	45.8%
Science is useful for solving problems in my everyday life.	47.8%	47.1%
Learning science will improve my career chances.	70.9%	71.5%
I have a good feeling toward science.	55.0%	56.7%
I enjoy talking to people about science.	24.6%	29.9%
I like writing about science.	13.3%	13.9%
I like to read books, magazines and Web sites about science.	22.9%	25.6%

There were no changes in rank order for the 15 Biotechnology Tasks Interest items and very little change in mean percents from pre to post-survey. The highest ranked tasks had content related to solving crimes and curing cancer. Students were ambivalent about the next six items. The remaining low-ranked items were essentially related to the mundane tasks of doing biotechnology.

The task for which the most students agreed they would like to perform was to ' Use clues from crime scenes to solve murder mysteries' (53% on the post). Very few students indicated a desire to maintain and troubleshoot equipment or to prepare biological materials for use in research. This suggests that the perceptions of working in the biotech industry is more positive to students at a higher level (crime scene investigator)than at the actual level of performing tasks in the biotech industry (preparing materials). It is interesting that only a third of all students were interesting in the stereotypical chemistry tasks related to test tubes, pipettes, etc.

TABLE 13: Student Survey Overall Means and Rank Order (Pre and Post) Biotech Tasks Interest Items

Item	Pre Mean	Pre Rank	Pre N	Pre STD	Post Mean	Post Rank	Post N	Post STD
Use clues from crime scenes to solve murder mysteries.	3.42	1	3985	1.25	3.37	1	3373	1.25
Discover cures for diseases like cancer.	3.25	2	4007	1.21	3.25	2	3374	1.21
Create new drugs to treat diseases.	3.05	3	4008	1.17	3.06	3	3387	1.19
Experiment with new ways to improve foods.	3.04	4	3996	1.16	3.00	4	3372	1.17
Invent substances used to make new products.	2.92	5	3991	1.13	2.90	5	3363	1.15
Alter DNA to change the characteristics of plants and animals.	2.89	6	3983	1.27	2.87	6	3372	1.27
Design a way to check for food poisons.	2.80	7	3999	1.12	2.84	7	3373	1.13
Work with test tubes, pipettes, beakers & other equipment in a laboratory.	2.78	8	3978	1.22	2.82	8	3377	1.21
Use computers to study the genetic code of living things.	2.77	9	3993	1.14	2.73	10	3373	1.15
Develop methods to detect bio-warfare agents such as anthrax.	2.73	10	4003	1.12	2.75	9	3378	1.16
Devise new ways to use bacteria and other microorganisms.	2.70	11	3993	1.14	2.73	11	3369	1.15
Design and perform biotech experiments in a laboratory.	2.67	13	3964	1.14	2.70	12	3371	1.17
Perform genetic tests to trace the evolution of plants and animals.	2.68	12	3978	1.20	2.67	13	3373	1.20
Prepare biological materials for use in research.	2.56	14	3971	1.06	2.58	14	3375	1.07
Maintain and troubleshoot equipment used in making products.	2.43	15	3963	1.01	2.47	15	3364	1.04

TABLE 14: Percent of Students that Agree/Agree Strongly - Biotech Interest Items

Item	Pre	Post
Create new drugs to treat diseases.	35.8%	40.2%
Discover cures for diseases like cancer.	46.0%	46.5%
Develop methods to detect bio-warfare agents such as anthrax.	24.5%	27.5%
Design a way to check for food poisons.	29.2%	31.8%
Alter DNA to change the characteristics of plants and animals.	36.6%	35.0%
Devise new ways to use bacteria and other microorganisms.	25.7%	26.7%
Use computers to study the genetic code of living things.	28.6%	27.2%
Invent substances used to make new products.	33.6%	33.6%
Experiment with new ways to improve foods.	38.7%	37.9%
Use clues from crime scenes to solve murder mysteries.	54.6%	52.5%
Perform genetic tests to trace the evolution of plants and animals.	27.3%	27.5%
Work with test tubes, pipettes, beakers & other equipment in a laboratory.	31.2%	32.5%
Prepare biological materials for use in research.	19.5%	20.1%
Design and perform biotech experiments in a laboratory.	25.2%	26.8%
Maintain and troubleshoot equipment used in making products.	14.1%	15.9%

The table below presents responses to items related to the extent of inquiry they experience in their science classroom. The largest positive change in mean scores was related to the item associated with actually conducting an investigation in the classroom. This item moved in rank from last to first on the pre and post survey, respectively.

TABLE 15: Student Survey Overall Means and Rank Order (Pre and Post) Classroom Inquiry Items

Item	Pre Mean	Pre Rank	Pre N	Pre STD	Post Mean	Post Rank	Post N	Post STD
I get to do real-life research.	3.46	1	3970	.93	3.56	2	3375	.99
I get to decide what data I need to answer my research questions.	3.29	2	3966	.96	3.34	3	3366	1.00
I get to decide how to go about answering my research questions.	3.28	3	3958	.97	3.29	4	3365	1.04
I get to share the answers to my research questions with my parents, community members, on the Internet, or with other people outside this classroom.	3.16	4	3967	1.03	3.20	5	3379	1.09
I usually get to come up with the research questions I want to answer.	2.98	5	3966	.99	3.00	6	3373	1.06
I have investigated at least one research question about DNA, genes, or another biotechnology topic in this class.	**2.96**	**6**	**3974**	**1.11**	**3.84**	**1**	**3381**	**1.07**

The table below shows the changes from pre to post on the classroom inquiry items in terms of percent of student agreement with each item. On the post-assessment, four out of the six items were agreed to by more than half of all students as compared to one of six on the pre-survey indicated strong overall gains.

TABLE 16: Percent of Students that Agree/Agree Strongly - Classroom Inquiry Items

Item	Pre	Post
I get to do real-life research.	55.9%	63.8%
I usually get to come up with the research questions I want to answer.	32.1%	36.7%
I get to decide how to go about answering my research questions.	47.7%	50.7%
I get to decide what data I need to answer my research questions.	48.6%	52.3%
I get to share the answers to my research questions with my parents, community members, on the Internet, or with other people outside this classroom.	41.1%	45.3%
I have investigated at least one research question about DNA, genes, or another biotechnology topic in this class.	**33.6%**	**72.1%**

Phase 1 Student Impact Summary

<u>Respondents</u>

- 4047 pre and 3404 post-surveys were submitted over 3 years (total=7451).
- Slightly more females than males submitted surveys.
- 71% of students were white, 6% did not answer, and the remaining 23% represented African American, Asian, Hispanic, Native American, Pacific Islander, and 'other.'
- 44% were in the 10th grade, 16% each were in 9th or 11th grade, and the remaining in grades 7, 8 and 12..
- Mean student age was 15.0 years at the time of the pre-survey.

<u>STEM Interest</u>

- 56% of students reported they will have taken four years of high school science.
- More females than males reported they will have taken four years of high school science.
- On both pre and post-surveys, about 53% of students named a post-secondary area of study related to a STEM career.
- More males than females expressed an interest in a STEM career.
- For those students whose pre and post-surveys could be matched on an ID number, the overall percent expressing an interest in STEM careers did not change from pre to post; but about 10% switched from STEM to non-STEM and another 10% switched from non-STEM to STEM career interest.
- There were differences between ethnic groups in terms of expressing an interest in STEM. A higher percentage of those identifying themselves as Asian or Pacific Islander expressed an

interest in STEM. The lowest percentage of expressed interest in STEM were from students self-identifying as Hispanic and Native American.

- The more high school science that was predicted by students, the more students reported an interest in a STEM career.
- Increased percentages from pre to post interest in STEM were found for students in grades 7, 9, and 12, while slight decreases were found for students in grades 8, 10, and 11.
- The increased interest in STEM from pre to post-survey was accounted for by proportionally more females than males.
- Of those that indicated an interest in STEM careers, there was an increase from pre to post in terms of the percent interested in a biological science field (62.0% and 64.5%, respectively).

Science Interest

- There were small, but positive changes from pre to post on 9 of 10 items.
- The largest positive changes pre to post dealt with students' enjoyment in talking about science.
- The items that ranked the highest were that learning science improves their career chances, that science is exciting, and that they had a good feeling toward science, with 55% to 71% agreeing with these statements.
- The items that ranked the lowest dealt with their enjoyment in talking, reading, and writing about science. 13% to 30% agreed with these statements.
- The rank order of items did not appreciably change from pre to post-survey.

Biotechnology Task Interest

- There were small, but positive changes from pre to post on 7 of 15 items.
- The items that ranked the highest were interest in solving murder mysteries and discovering cures for diseases with 46% to 53% agreeing they would like to do those tasks .
- The items that ranked the lowest dealt with maintaining equipment, preparing biological materials for research, and performing genetic tests with only 14% to 27% agreeing they would like to do those tasks.
- Rank order of items did not appreciably change from pre to post-survey.

Classroom Inquiry

- There were positive (small to moderate) changes from pre to post on three items: (1) I get to do real-life research, (2) I get to decide what data I need, and (3) I have investigated at least one research question related to biotechnology in this class.
- The percent of students that indicated they had investigated at least one biotech research question jumped from 34% on the pre to 72% on the post survey.
- The item that the smallest percentage of students agree with on the post-survey was that they got to come up with their own research question.
- Overall, a greater percentage of students on the post as compared to the pre indicated they were engaged in scientific inquiry in their classrooms.

Overall, there were positive changes from pre to post on most items related to science interest, biotechnology task interest, and classroom inquiry. There were no systematic differences, however, between students whose teachers completed different phases of the program. The effects due to the project are difficult to detect in whole classrooms across an entire year since the biotech implementation is just one (often small) set of learning experiences.

However, one teacher stands out (referred to as *Focus Teacher*) in terms of student gains in interest in science and biotechnology tasks, perception of classroom-based inquiry, and interest in STEM careers. This teacher is unique as compared to the majority of her colleagues in that her class was fully dedicated to biotechnology research. Over three years, the percent of students in this class interested in STEM careers jumped from about 40% to 64% pre to post. Of these, about 60% were interested in biology at the time of the pre as compared to 80% on the post.

The mean score for this teacher's students on the pre for the science interest scale was 2.4 (3=neutral) whereas on the post the mean score was 3.3. Notable changes from pre to post on this scale were, for example, that only 27% agreed that science was exciting on the pre as compared to 69% on the post; solving science problems is fun (26% to 53%); and I like science more than most other subjects (20% to 69%). Only 9% of students indicated on the pre they enjoyed talking to others about science as compared to 45% on the post.

Similar results were found for the biotechnology tasks scale. Only 14% of students indicated an interest in designing and performing biotech experiments on the pre as compared to 38% on the post. On the post-survey, 47% reported an interest in devising new ways to use bacteria and other microorganisms, up from 17% on the pre. Changes in perception about classroom inquiry were particularly large and positive.

TABLE 17: Focus Teacher Student Results

	Percent Agreeing	
Item	Pre	Post
I get to do real-life research.	37%	86%
I usually get to come up with the research questions I want to answer.	25%	82%
I get to decide how to go about answering my research questions.	38%	71%
I get to decide what data I need to answer my research questions.	41%	78%
I get to share the answers to my research questions with my parents, community members, on the Internet, or with other people outside this classroom.	26%	55%
I have investigated at least one research question about DNA, genes, or another biotechnology topic in this class.	25%	82%

The importance of highlighting one teacher is to illustrate that a course dedicated to scientific inquiry can have significant effects on student interest in science. That is, when scientific inquiry is the overarching task that students participate in a daily basis, this experience appears to be qualitatively

different than for students in courses where biotech labs are integrated into a broader curriculum. Thus, the effects of teacher training on student performance is much easier to detect since the entire curriculum is focused on inquiry, research and lab skills.

Student Impact - Phase 2

Data were collected from students participating in the Phase 2 summer research experience with their dedicated teachers. Two cohorts engaged in research during the summers of 2007 and 2008.

TABLE 18: Gender Distribution for Each Phase 2 Student Cohort

		Cohort Year		Total
		2007	2008	
Gender	Female	9	10	19
	Male	7	2	9
Total		16	12	28

At the beginning of the Phase 2 experience, students were asked to assess their current skill levels on a variety of biotechnology tasks. Students also completed a post-self assessment at the end of the summer experience. Teachers also rated students pre and post on these items. The six skill categories and their associated reliability values were:

1. Research Competencies (Chronbach's alpha: .818)
2. General Laboratory Skills (Chronbach's alpha: .848)
3. Working with DNA (Chronbach's alpha: .688)
4. Microbiological Techniques (Chronbach's alpha: .850)
5. Biochemical Techniques (Chronbach's alpha: .689)
6. Bioinformatics (Chronbach's alpha: .711)

Students and teachers rated the specific skills within each competency category according to the following scale:

1. Newby
2. Beginner
3. Advanced Beginner
4. Apprentice
5. Master

A mean for each competency area was computed by summing the total points received and dividing by the number of skills within the category. In the table below, the means for the pre and post-self assessments by students are presented. In every category there was a significant increase from pre to post-assessment.

TABLE 19: Phase 2 Student Self Assessment

	Pre			Post		
Category	N	Mean	STD	N	Mean	STD
Research Competencies (Self)	27	2.9	.6	26	3.7	.4
General Laboratory Skills (Self)	27	2.9	.9	26	4.2	.6
Working with DNA (Self)	27	1.9	.7	26	3.5	.5
Microbiological Techniques (Self)	26	1.9	1.1	26	3.9	.8
Biochemical Techniques (Self)	26	1.2	.5	26	2.0	1.0
Bioinformatics (Self)	26	1.3	.5	26	2.7	.9

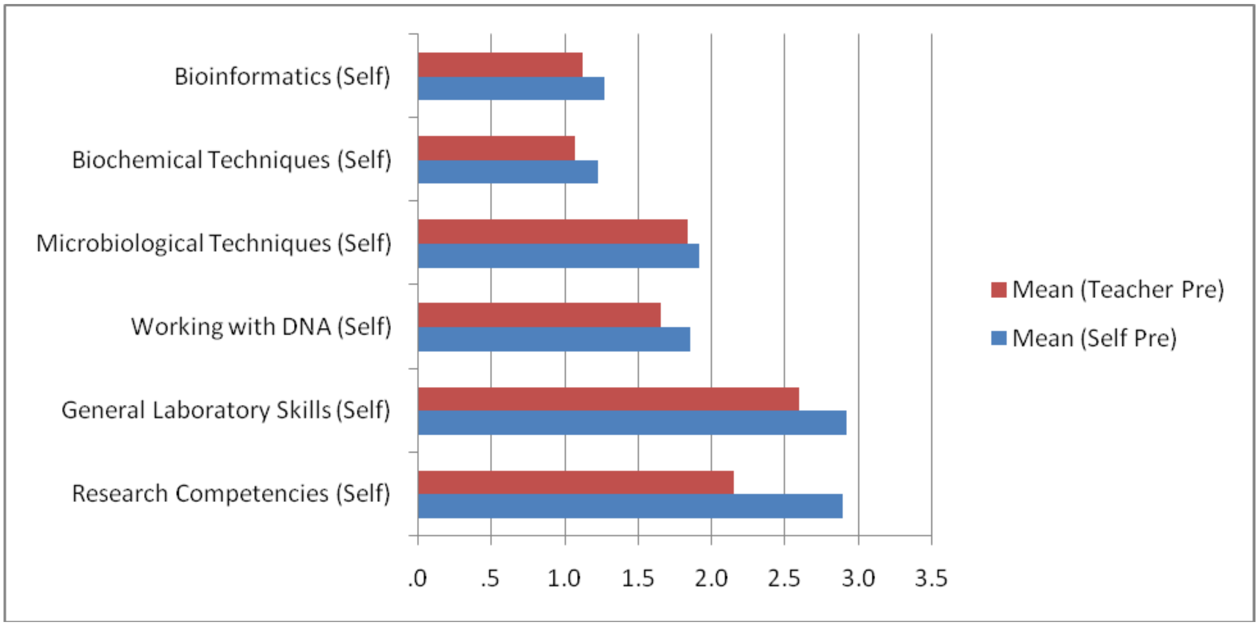
The table below presents the mean scores calculated from the ratings of the teachers on their students on the pre and post scores. As with student scores, there was an increase in teacher ratings of students in every category.

TABLE 20: Phase 2 Teacher Assessment of Student

	Pre			Post		
Category	N	Mean	STD	N	Mean	STD
Research Competencies (Teacher)	28	2.1	.8	27	3.5	.6
General Laboratory Skills (Teacher)	28	2.6	.9	27	3.6	.7
Working with DNA (Teacher)	28	1.7	.7	27	2.9	.7
Microbiological Techniques (Teacher)	28	1.8	.9	27	3.4	1.2
Biochemical Techniques (Teacher)	28	1.1	.4	27	1.5	.9
Bioinformatics (Teacher)	28	1.1	.4	27	2.0	.9

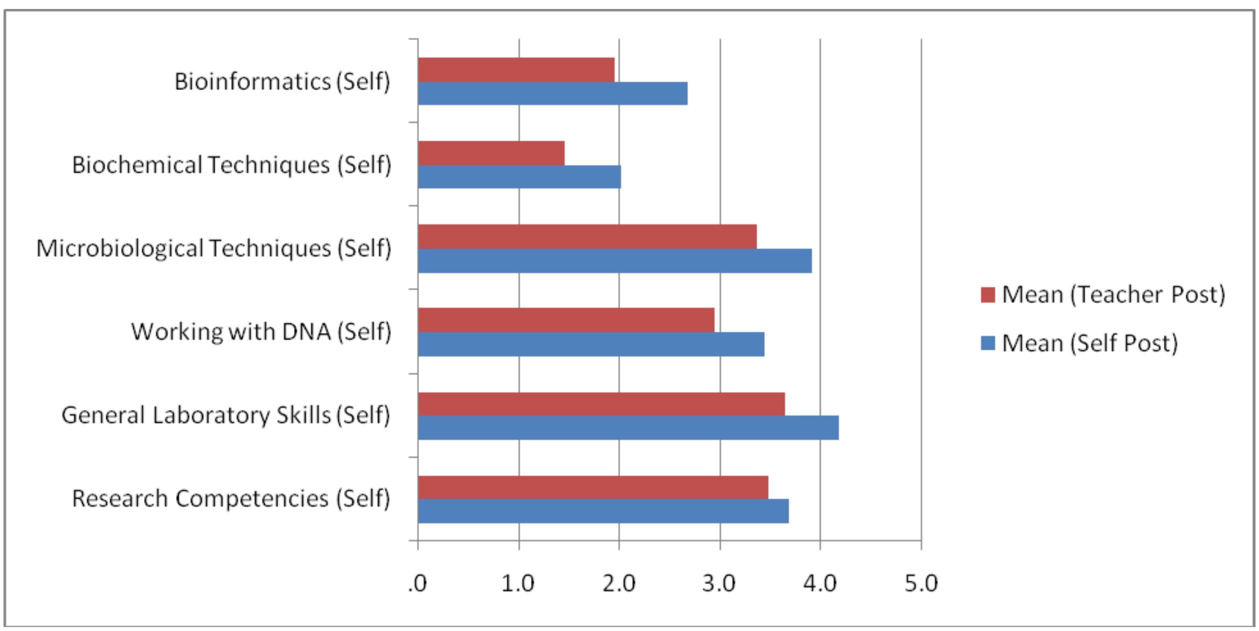
The chart below presents a comparison of student to teacher assessment of skills in the biotech competency areas.

CHART 4: Student and Teacher Pre Assessments of Student



The chart below compares student and teacher ratings of the students skills on the post assessment.

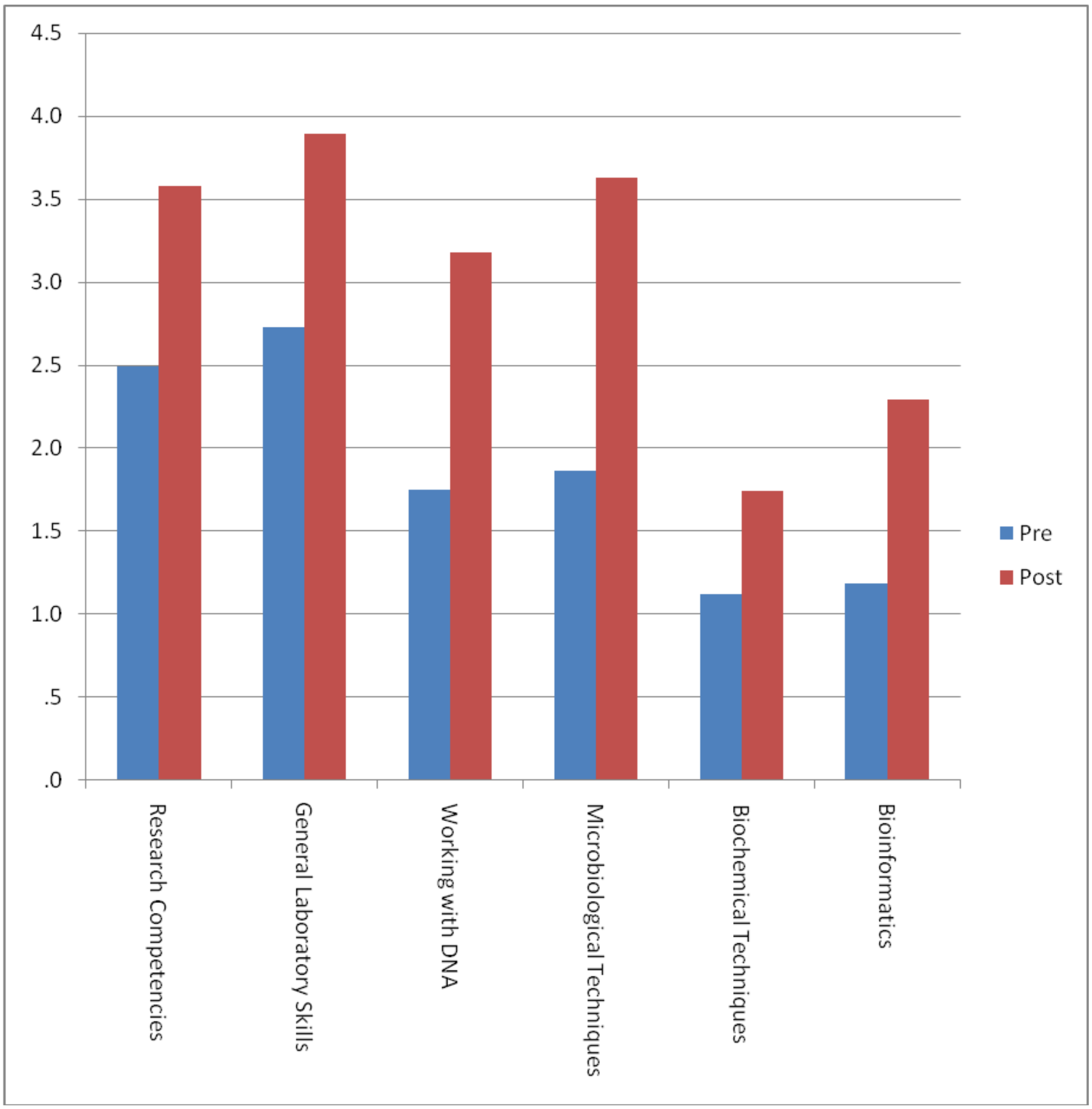
CHART 5: Student and Teacher Post Assessments of Student



Students overall tended to rate themselves higher on both the pre and post-assessments (the mean for all assessment items computed) than the ratings of the teachers. On average, students scored 2.2 and

3.5 (out of 5 points possible) on the pre and post-assessments, respectively, as compared to scores of 1.9 and 3.0 as rated by their teachers. However the gains from pre to post overall reflected an overall 37% increase in the ratings of both students and teachers. The difference is that teacher overall scores on pre and post were about 15% lower than the student overall scores. (Students tend to score themselves higher than how teachers score them.) The chart below compares the overall pre and post scores for each category (teacher and student ratings combined). Significant gains were made in all competency areas.

CHART 6: Overall Assessments of Student by Biotechnology Competency Area



TEACHER RESULTS: Phases One, Two and Three

Phase 1 Summer Institute: Teacher Results

Week 1 Survey

Each entering cohort of teachers was administered a survey at 3 points in time: (a) On the first day of Week One of the Phase One BEI Istitute referred to as the 'pre'; (b) on the Friday of Week One referred to as the 'post'; and (c) at the endof the school year, referred to as the 'end-of-year' (EOY). The goal of the post-survey was to determine immediate changes reported by the teachers as a result of Week One activities. The goal of the end-of-year survey was to determine the extent to which changes from pre to post were sustained over the course of the year. Teachers were also asked to complete the end-of-year survey each year after their attendance at the BEI Institute.

Survey items were developed collaboratively by the BEI project team. The survey was identical for all administrations. The first 15 items used a Likert format and asked teachers to rate the extent of their agreement (strongly disagree, disagree, neutral, agree, strongly agree) with each statement. For analysis, the response choices were assigned values of 1, 2, 3, 4, and 5, respectively. These items were:

1. I have a personal interest in science.
2. I understand what biotechnology is.
3. I am very knowledgeable about biotechnology careers that my students can potentially enter some day.
4. I can describe in some detail job tasks that a biotechnology graduate might work on in a biotechnology company.
5. In my school's curriculum I know which courses students must take in order to enter a biotechnology career path.
6. I am very knowledgeable about the biotechnology program in at least one community college and/or university that my students might potentially enter some day.
7. I know how to collaborate with counselors to better prepare students to enter biotechnology career paths.
8. Biotechnology is one of the top 5 career paths for college-bound students in my school.
9. Biotechnology careers are only appropriate for the most elite science students in my school.
10. My science knowledge and skills are adequate to effectively prepare students to enter biotechnology careers.
11. My math knowledge and skills are adequate to effectively prepare students to enter biotechnology careers.
12. My biotechnology knowledge and skills are adequate to effectively prepare students to enter biotechnology careers.
13. I am prepared to overcome the challenges associated with increasing the number of students who enter biotechnology career paths.
14. I have specific strategies in mind that I will try in the near future to increase the number of students who enter biotechnology career paths.
15. To me science is often intimidating.

A total of 69 teachers responded to these surveys.

On the pre-survey, the lowest rated items were that *science was intimidating* and that *biotech careers were only appropriate for the most elite science students* in their schools. Teachers clearly disagreed with these statements and these ratings were sustained on the post and end-of-year surveys. These items reflect the teachers' comfort with science as well as their commitment to all students learning science, especially biotech. In spite of these results, the third lowest rated item was that biotechnology is one of the top five career paths for college-bound students in their schools.

The next three lowest rated items on the pre also showed the greatest increase in rating on the post and even higher on the end-of-year. These dealt with the teachers' knowledge level about the biotech program in at least one community college or university, their ability to describe in some detail job tasks related to biotechnology, and their comfort in collaborating with counselors. Each of these items received a 'disagree' rating on the pre, on average, but an ‘agree’ or higher on the post and end-of-year surveys.

On the pre, teachers were mostly neutral that their biotech knowledge and skills were adequate to effectively prepare students to enter biotech careers, but ‘agree’ on the post and end-of-year surveys that they were adequate.

There were three other items on which teachers were neutral on the pre that also showed jumps to ‘agree’ on the post and end-of-year surveys. These dealt with their knowledge of biotech careers, that they had specific strategies in mind to increase the number of students who enter biotech careers, and their knowledge of what courses student must take to enter a biotech career path.

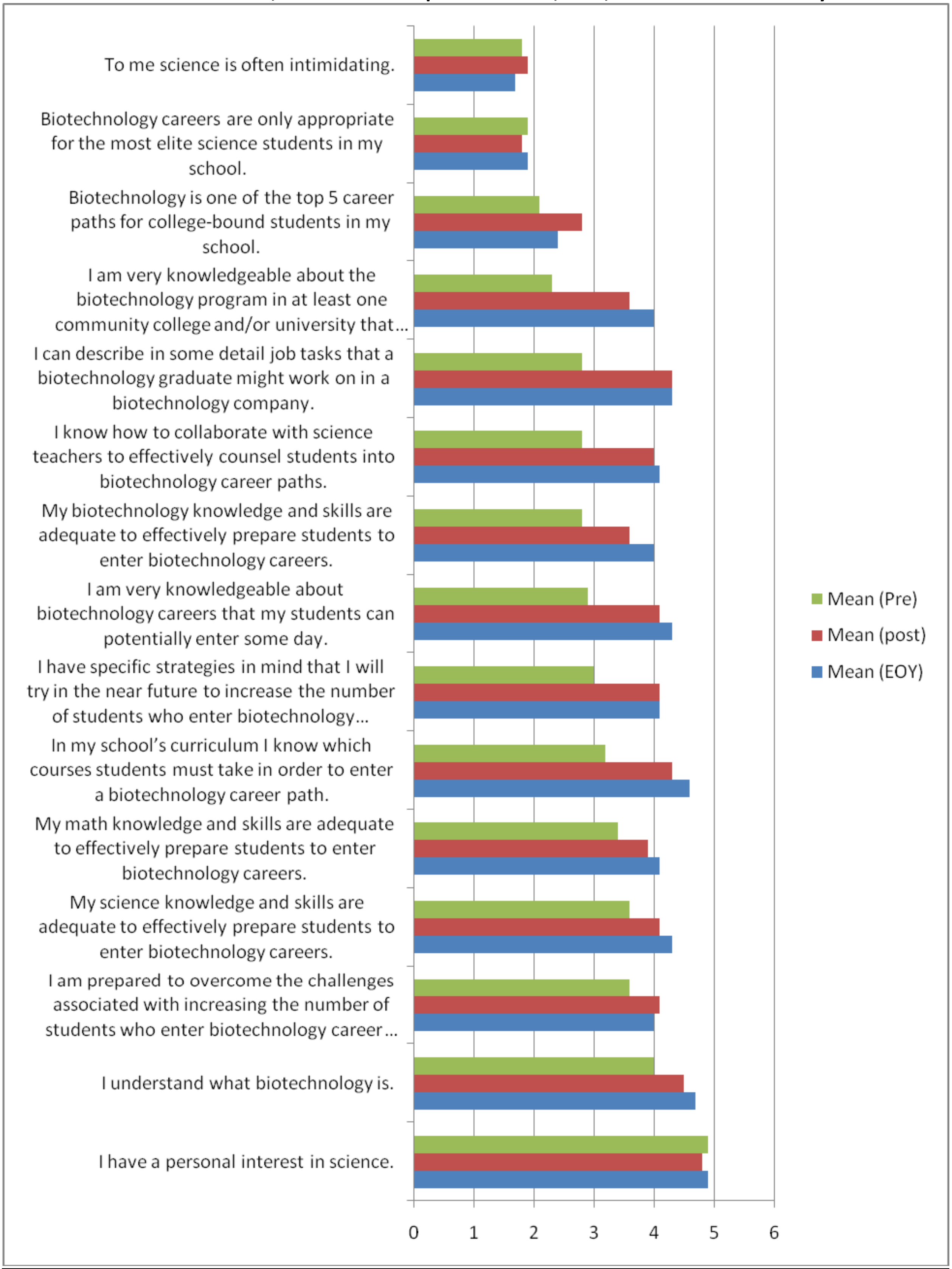
There was a small, but positive change from pre to post to end-of-year on both the assessment of the teachers' requisite math and science knowledge and skills, as well as their feeling of preparedness to overcome challenges associated with increasing the number of students entering biotech careers. There were slight rating increases with respect to teachers' understanding of the definition of biotech, but no change in their personal interest in science. Results are given in the table below. The columns titled Post-Pre, EOY-Pre and EOY-Post are calculations that reflected changes in the mean for each item from the pre to the post-survey, from the pre to the end-of-year survey, and from the post to the end-of-year survey. These represent self-reported changes after Week One of the BEI Institute, changes after an academic year after the pre-survey, and the extent to which changes on the post were sustained by the end of the year.

When disaggregated by cohort year, the results of the pre, post and end-of-year surveys did not vary to great extent in terms of the rank order or magnitude of ratings for the items. Chronbach's Alpha (reliability) for these 15 items across all three survey administrations was .786, which reflects a good measure of internal consistency for this survey.

TABLE 21: Means and Ranks of Phase 1, Week One Survey Pre, Post, and End of Year

Item	Mean (Pre)	Rank (Pre)	STD (pre)	Mean (post)	Rank (post)	STD (post)	Mean (EOY)	Rank (EOY)	Std. Deviation	Post-Pre	EOY-Pre	EOY-Post
I have a personal interest in science.	**4.9**	1	.3	**4.8**	1	.6	**4.9**	1	.3	-.1	.0	.1
I understand what biotechnology is.	**4.0**	2	.9	**4.5**	2	.5	**4.7**	2	.4	.4	.7	.2
I am prepared to overcome the challenges associated with increasing the number of students who enter biotechnology career paths.	**3.6**	3	1.1	**4.1**	8	.7	**4.0**	10	.7	.4	.4	.0
My **science** knowledge and skills are adequate to effectively prepare students to enter biotechnology careers.	**3.6**	4	.9	**4.1**	7	.8	**4.3**	6	.5	.5	.7	.2
My **math** knowledge and skills are adequate to effectively prepare students to enter biotechnology careers.	**3.4**	5	.9	**3.9**	10	.8	**4.1**	8	.7	.4	.6	.2
In my school's curriculum I know which courses students must take in order to enter a biotechnology career path.	**3.2**	6	1.2	**4.3**	3	.7	**4.6**	3	.6	1.1	1.3	.3
I have specific strategies in mind that I will try in the near future to increase the number of students who enter biotechnology career paths.	**3.0**	7	.9	**4.1**	5	.6	**4.1**	9	.6	1.1	1.0	-.1
I am very knowledgeable about biotechnology careers that my students can potentially enter some day.	**2.9**	8	1.1	**4.1**	6	.7	**4.3**	5	.4	1.2	1.4	.2
My **biotechnology** knowledge and skills are adequate to effectively prepare students to enter biotechnology careers.	**2.8**	9	.9	**3.6**	11	.9	**4.0**	11	.7	.8	1.2	.4
I know how to collaborate with science teachers to effectively counsel students into biotechnology career paths.	**2.8**	10	1.0	**4.0**	9	.6	**4.1**	7	.6	1.2	1.3	.1
I can describe in some detail job tasks that a biotechnology graduate might work on in a biotechnology company.	**2.8**	11	1.1	**4.3**	4	.6	**4.3**	4	.5	1.5	1.6	.1
I am very knowledgeable about the biotechnology program in at least one community college and/or university that my students might potentially enter some day.	**2.3**	12	.9	**3.6**	12	1.0	**4.0**	12	.8	1.3	1.7	.4
Biotechnology is one of the top 5 career paths for college-bound students in my school.	**2.1**	13	.8	**2.8**	13	1.0	**2.4**	13	.7	.6	.3	-.3
Biotechnology careers are only appropriate for the most elite science students in my school.	**1.9**	14	.8	**1.8**	15	.7	**1.9**	14	.7	.0	.0	.0
To me science is often intimidating.	**1.8**	15	.9	**1.9**	14	1.0	**1.7**	15	.8	.1	-.1	-.2

CHART 7: Phase 1, Week One Comparison of Pre, Post, and End of Year Surveys



Week Two Survey

Teachers remained for Week Two of the BEI Institute and were given a pre and post-surveys as they worked on inquiry and lab skill development. Fifteen items were developed by the project team that addressed issues related to teaching biotech. The 15 Likert items used the same response scale as the Week One survey. The items were:

1. I know what inquiry-based science instruction is.
2. I am skilled at using an inquiry-based approach in my science teaching.
3. I know what supplies and materials I need in my classroom to successfully implement the biotech instructional unit that I will be developing and teaching for the BEI project.
4. I have strategies for obtaining the biotechnology supplies and materials I need to teach biotech units in my curriculum.
5. I know exactly where in my curriculum I am going to implement the biotechnology unit I am creating at this BEI institute.
6. I have a detailed unit plan for the biotechnology unit I am going to teach this upcoming year for the BEI project.
7. I am comfortable with the process of developing biotechnology instructional units for my curriculum.
8. I know how to create new biotechnology instructional units on my own and/or with colleagues at my school.
9. Implementing new biotechnology instructional units in my curriculum is feasible.
10. I am confident I can transform an existing instructional unit in my curriculum into an inquiry-based unit.
11. I am confident that the implementation of inquiry-based biotechnology units in my curriculum will **NOT** jeopardize my students' performance on standardized testing.
12. The inquiry-based biotechnology units I plan to implement in my curriculum this coming year will help my students perform better on standardized tests.
13. I know how to align my biotechnology instructional units with state and national standards.
14. I am prepared to overcome any challenges associated with increasing the number of my students who enter biotechnology career paths.
15. I have specific strategies in mind that I will try in the near future to increase the number of my students who enter biotechnology career paths.

These items were the same on both pre and post-survey administrations. A total of 69 teachers responded to these surveys. The top rated nine items (i.e., on average the statements were 'agreed to') also showed the least change from pre to post-survey. Teachers in Week Two reported they knew what inquiry-based science instruction was, that implementing inquiry-based instruction would not jeopardized standardized test performance, that they could transform traditional instruction into inquiry-based instruction, that this was feasible, and that they were prepared to meet the challenges of increasing the number of students who go into biotech careers. Additionally, they felt they were skilled in using inquiry-based instruction and they knew how to align biotech units with their mandated standards.

Teachers were neutral about five items on the pre, but agreed on the post with the following statements:

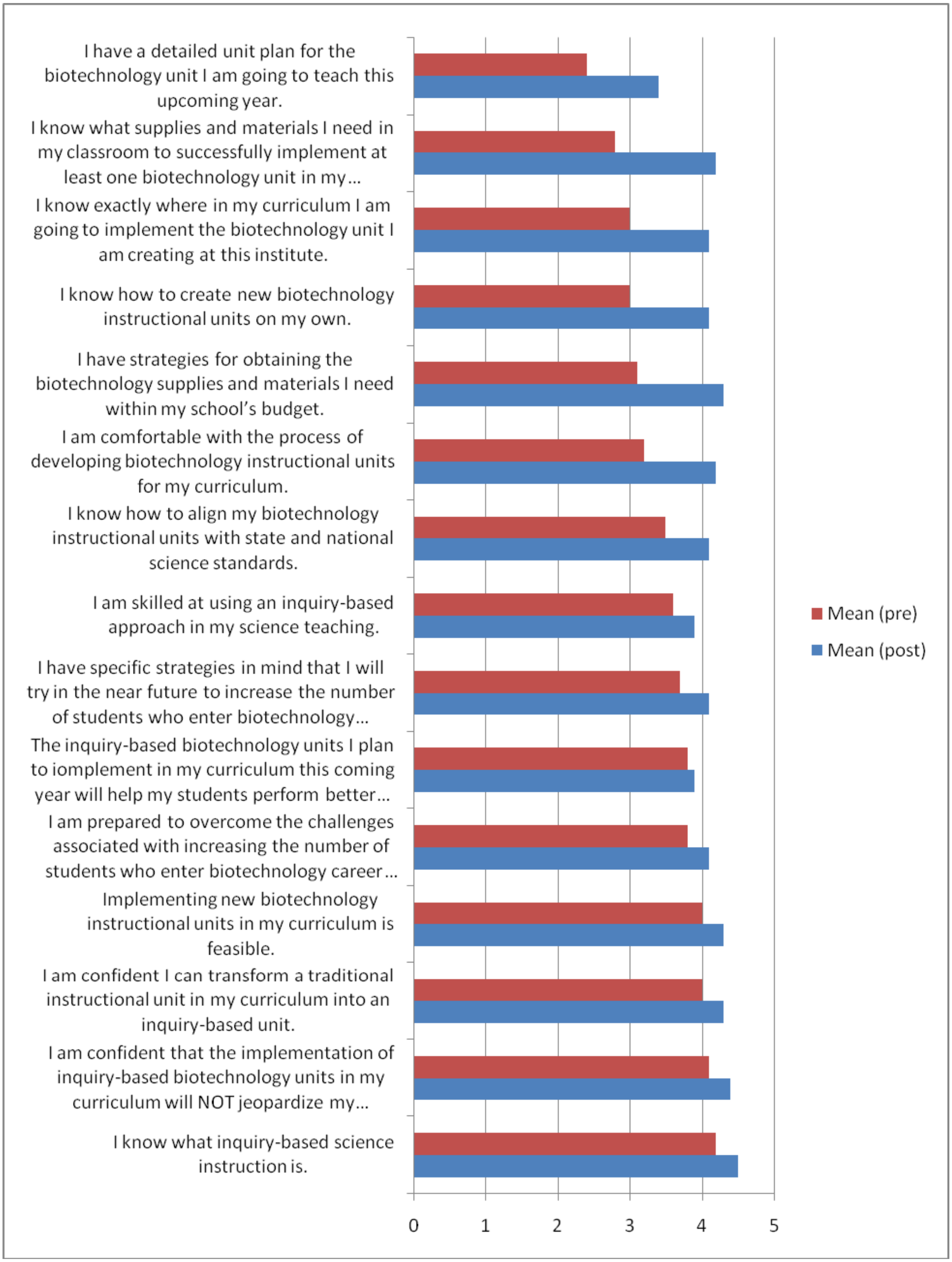
- I am comfortable with the process of developing biotechnology instructional units for my curriculum.
- I have strategies for obtaining the biotechnology supplies and materials I need within my school's budget.
- I know how to create new biotechnology instructional units on my own.
- I know exactly where in my curriculum I am going to implement the biotechnology unit I am creating at this institute.
- I know what supplies and materials I need in my classroom to successfully implement at least one biotechnology unit in my curriculum.

One item changed from 'slightly disagree', on average, to slightly 'agree: ' I have a detailed unit plan for the biotechnology unit I am going to teach this upcoming year.' Results and rankings are given in the table below.

TABLE 22: Phase 1, Week Two Pre Post Teacher Results

Item	Mean (pre)	Rank (pre)	STD (pre)	Mean (post)	Rank (post)	STD (post)	Post - Pre
I know what inquiry-based science instruction is.	4.2	1	.8	4.5	1	.7	0.2
I am confident that the implementation of inquiry-based biotechnology units in my curriculum will NOT jeopardize my students' performance on standardized testing.	4.1	2	.8	4.4	2	.8	0.3
I am confident I can transform a traditional instructional unit in my curriculum into an inquiry-based unit.	4.0	3	.7	4.3	3	.6	0.3
Implementing new biotechnology instructional units in my curriculum is feasible.	4.0	4	.6	4.3	4	.5	0.3
I am prepared to overcome the challenges associated with increasing the number of students who enter biotechnology career paths.	3.8	5	.7	4.1	10	.6	0.3
The inquiry-based biotechnology units I plan to implement in my curriculum this coming year will help my students perform better on standardized tests.	3.8	6	.8	3.9	14	.8	0.1
I have specific strategies in mind that I will try in the near future to increase the number of students who enter biotechnology career paths.	3.7	7	.9	4.1	12	.5	0.4
I am skilled at using an inquiry-based approach in my science teaching.	3.6	8	1.0	3.9	13	.8	0.3
I know how to align my biotechnology instructional units with state and national science standards.	3.5	9	1.0	4.1	8	.8	0.6
I am comfortable with the process of developing biotechnology instructional units for my curriculum.	3.2	10	1.1	4.2	7	.5	1.0
I have strategies for obtaining the biotechnology supplies and materials I need within my school's budget.	3.1	11	1.1	4.3	5	.5	1.1
I know how to create new biotechnology instructional units on my own.	3.0	12	1.1	4.1	9	.6	1.1
I know exactly where in my curriculum I am going to implement the biotechnology unit I am creating at this institute.	3.0	13	1.1	4.1	11	.7	1.1
I know what supplies and materials I need in my classroom to successfully implement at least one biotechnology unit in my curriculum.	2.8	14	1.0	4.2	6	.5	1.4
I have a detailed unit plan for the biotechnology unit I am going to teach this upcoming year.	2.4	15	1.0	3.4	15	.9	1.0

CHART 8: Changes Pre to Post on Week Two Teacher Survey



At the end of Week Two of the BEI Institute, teachers were asked to list all of the biotech skills they had participated in and/or learned during the past week. Teachers listed a total of 194, 134 and 215 skills at the conclusion the Year One, Two and Three BEI Institutes, respectively. Of these 91, 59 and 136 were new to the teachers, respectively. On average, then, each teacher participant listed eight biotech skills they participated in, and of these half were new. That is, each teacher, at the end of Week Two, reported that he or she had learned four new biotech skills during the past week. These skills were distributed into nine categories. The skills categories and prototypical examples are given in the table below.

TABLE 23: Biotechnology Skills Learned by Teachers, Week Two, Phase 1

CATEGORY	Year One Example	Year Two Example	Year Three Example
Lab Skills/ Techniques	Filling wells with a pipette	Micro pippetting, using the new equipment	Make sure you write down details especially in lab so they are repeatable and you can look back and compare to what happened, etc
Working with DNA	Separating DNA from soil	DNA extraction from bacteria (to spool the DNA, to purify plasmid DNA, and to obtain template for PCR)	Adding a particular gene to an organism to change the makeup of their DNA (pGLO)
Working with Gels	Formulating Agarose gels and pouring them	Running gel electrophoresis boxes	Reading results from gel electrophoresis
Resources and Research Knowledge	Bioinformatics - how to look up genome of organism of interest and locus of interest at NCBI web site	How to find new information on just about anything in the field biotechnology	Networking with other professionals
Group Collaboration	Problem solving in a group	Collaboration	Collaboration with other science educators/
Working with Solutions/Chemicals	Making solutions (with the correct concentrations)	Creation of a 1M NaCl solution	pH testing
Working with Bacteria	Bacterial concentration and analysis	The culturing and streaking of bacterial plates and the subsequent isolation of bacteria for manipulation	Growing bacterial cultures
Working with Proteins/Enzymes	Protein chromatography (purification of proteins)		ELISA-Tracking diseases ELISA protocol is new to me
Lab Instruments	Understanding how a thermo cycler works	The use of thermo cycler to aid in the incorporation of plasmids into bacteria without destroying them	Centrifuging the liquids to separate the \pill\ from the supernatant

The skills listed most often were in the categories of Lab Skills & Techniques, Working with DNA, and Working with Gels. These accounted for almost two-thirds of all skills mentioned.

Teacher Impact - Phase 2

Data were collected from teachers participating in the Phase 2 summer research experience with their dedicated researchers. Two cohorts engaged in research during the summers of 2007 and 2008.

TABLE 24: Gender Distribution for Each Phase 2 Student Cohort

		Cohort Year		Total
		2007	2008	
Gender	Female	1	4	5
	Male	6	2	8
Total		7	6	13

At the beginning of the Phase 2 experience, teachers were asked to assess their current skill levels on a variety of biotechnology tasks. Teachers also completed a post-self assessment at the end of the summer experience. Researchers also rated teachers pre and post on these items. The six skill categories were:

1. Research Competencies
2. General Laboratory Skills
3. Working with DNA
4. Microbiological Techniques
5. Biochemical Techniques
6. Bioinformatics

Researchers and teachers rated the specific skills within each competency category according to the following scale:

1. Newby
2. Beginner
3. Advanced Beginner
4. Apprentice
5. Master

A mean for each competency area was computed by summing the total points received and dividing by the number of skills within the category. In the table below, the means for the pre and post self assessments by teachers are presented. In every category there was a significant increase from pre to post-assessment.

TABLE 25: Teacher Self Rating Pre and Post, Phase 2

	Pre			Post		
Category	**N**	**Mean**	**STD**	**N**	**Mean**	**STD**
Research Competencies (Self)	12	2.9	.8	13	4.1	.6
General Laboratory Skills (Self)	12	3.4	.8	13	4.3	.6
Working with DNA (Self)	12	2.1	.6	13	3.4	.6
Microbiological Techniques (Self)	12	2.9	1.0	13	4.1	.9
Biochemical Techniques (Self)	12	1.2	.4	13	1.7	.9
Bioinformatics (Self)	12	1.3	.6	13	2.5	1.1

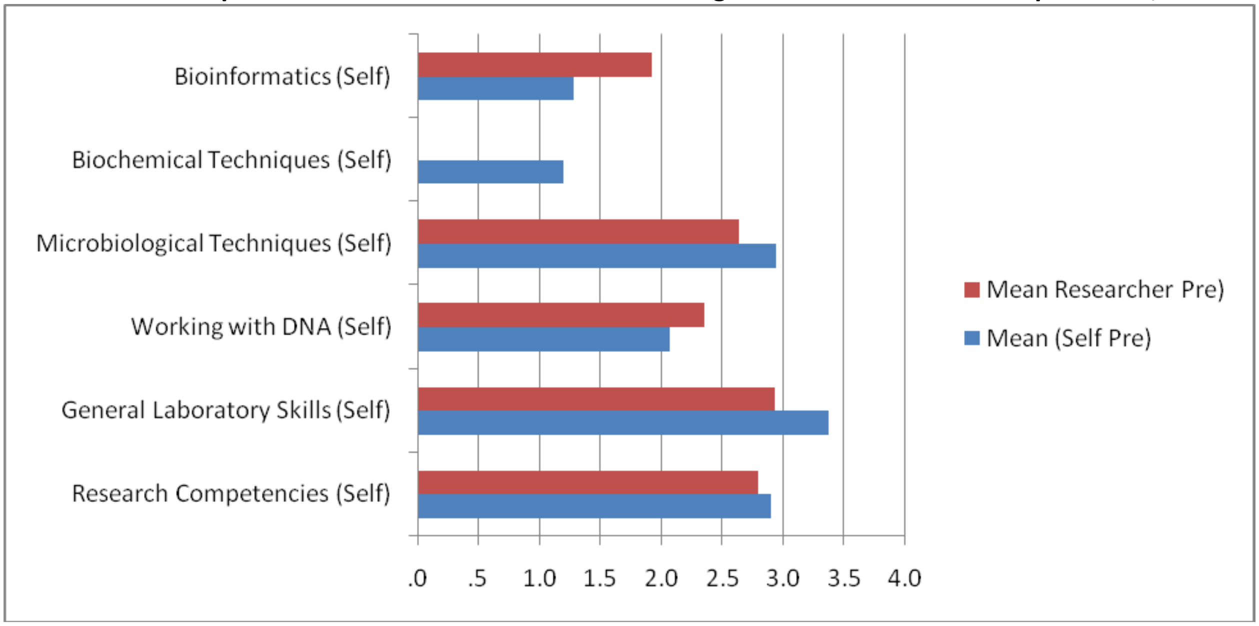
The table below presents the mean scores calculated from the ratings of the researchers on their teachers on the pre and post-scores. As with teacher scores, there was an increase in researcher ratings of teachers in every category. Data is missing for the category 'Biochemical Techniques' because researchers did not have an opportunity to observe skills in this category on the pre-assessment, and only three observed it on the post-assessment. It is also the lowest rated competency area of teachers on both their pre and post-assessments. Thus, this category is removed from computations in the overall analysis.

TABLE 26: Researcher Rating of Teachers Pre and Post, Phase 2

	Pre			Post		
Category	**N**	**Mean**	**STD**	**N**	**Mean**	**STD**
Research Competencies (Researcher)	12	2.8	.7	11	4.4	.6
General Laboratory Skills (Researcher)	12	2.9	.8	11	4.4	.7
Working with DNA (Researcher)	12	2.4	.8	11	4.6	.3
Microbiological Techniques (Researcher)	12	2.6	1.0	11	4.7	.5
Biochemical Techniques (Researcher)	0			3	3.3	.6
Bioinformatics (Researcher)	12	1.9	.6	11	3.7	.8

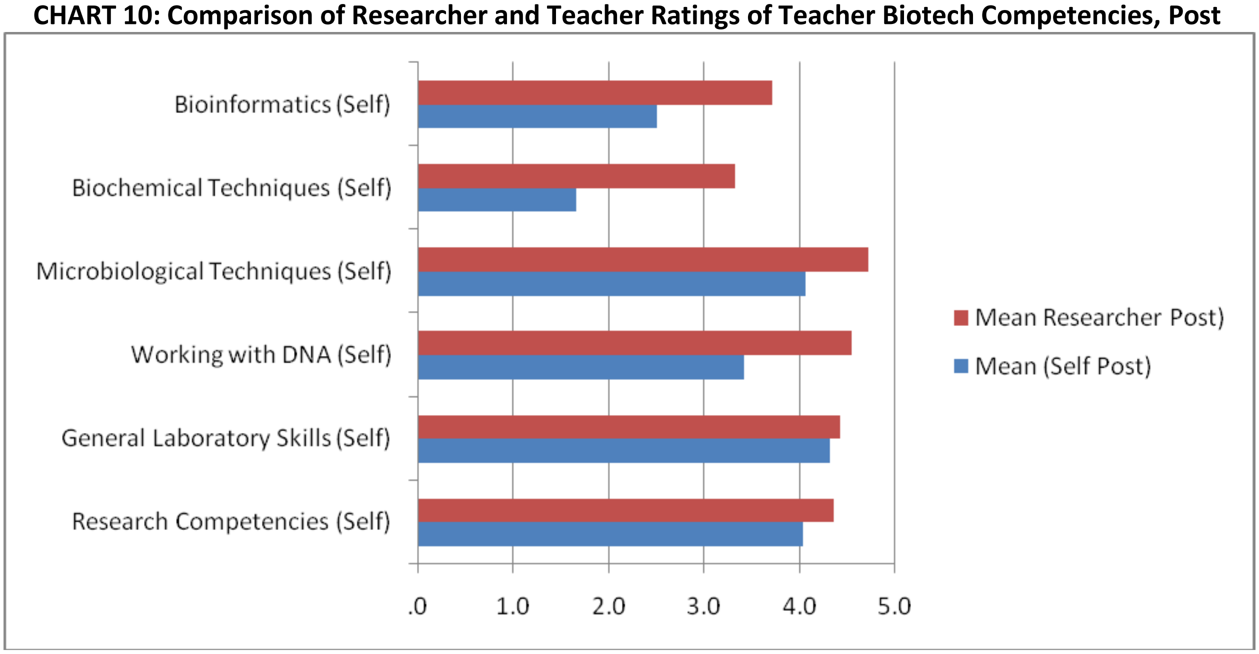
The chart below presents a comparison of teacher to researcher assessment of skills in the biotech competency areas on the pre-assessment.

CHART 9: Comparison of Researcher and Teacher Ratings of Teacher Biotech Competencies, Pre



The chart below compares teacher and researcher ratings of the teacher skills on the post assessment.

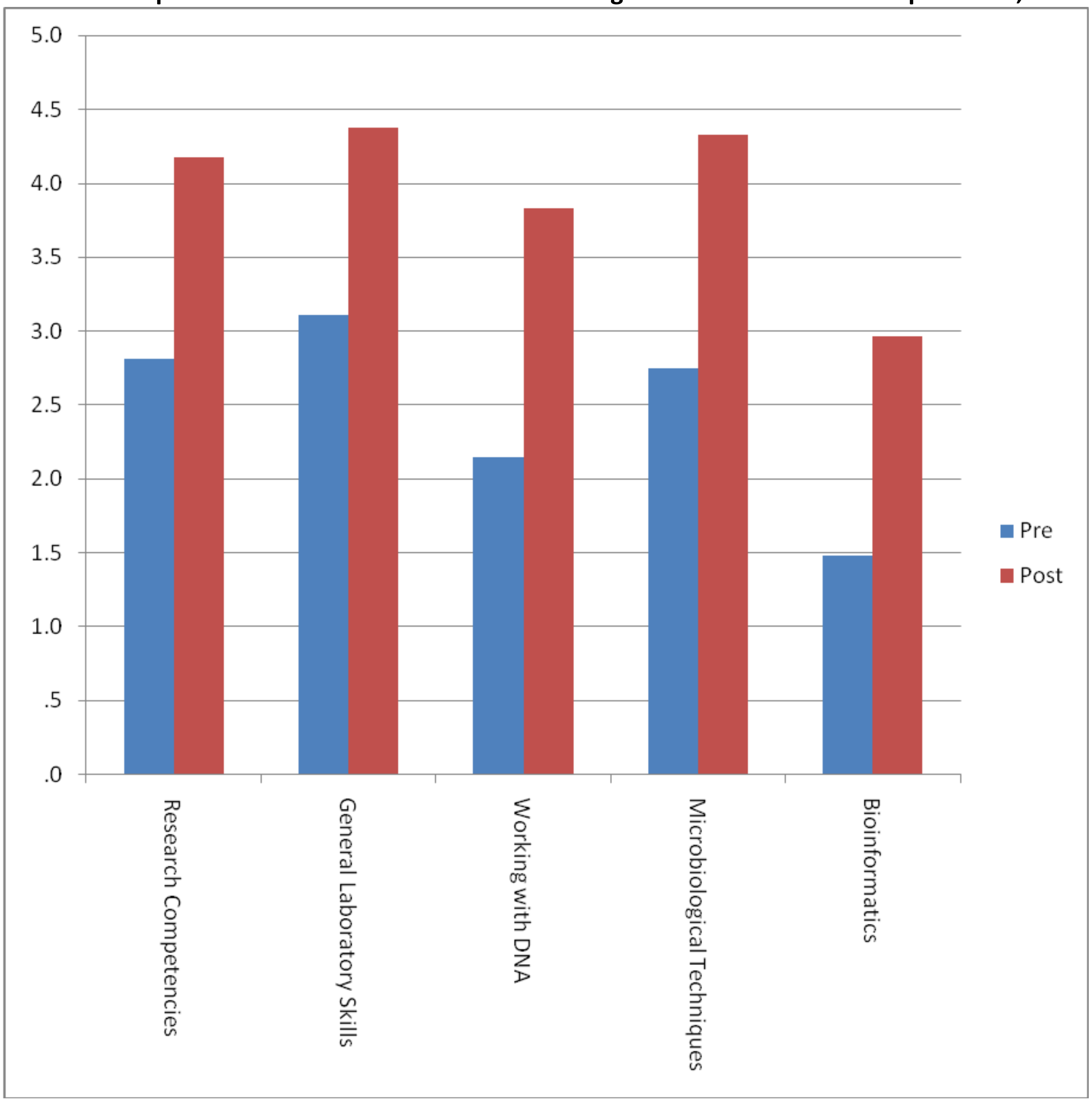
CHART 10: Comparison of Researcher and Teacher Ratings of Teacher Biotech Competencies, Post



Teachers overall tended to rate themselves about the same on the pre assessment as the researchers rated the teachers, but teachers rated themselves considerably lower on the post-assessment than did the researchers. On average, teachers scored 2.6 and 3.8 (out of 5 points possible) on the pre and post assessments, respectively, as compared to scores of 2.6 and 4.4 as rated by their researchers. The gains from pre to post reflected an overall 31% increase in the self-ratings by the teachers, while the increase in the ratings given to teachers by researchers was a 41% gain. In other words, the teachers and researchers rated teachers about the same on the pre assessment, but researchers felt the teachers made more gains than did the teachers themselves.

The chart below compares the overall pre and post scores for each category (teacher and researcher ratings combined). Significant gains were made in all competency areas.

CHART 11: Comparison of Researcher and Teacher Ratings of Teacher Biotech Competencies, Overall



Teacher Impact – Phase Three

Four Phase Two teachers self-selected to participate in the Phase Three five-week industry internship experience. All were veteran teachers. Two had science Masters Degrees; one is working on an education Masters degree; and the other is not pursuing an advanced degree at the time. Each was asked at the beginning of their industry experience to list three Goal Statements:

Name	Goal 1	Goal 2	Goal3
Field	Determine the skill and knowledge sets most sought after by private industry.	See if I can acquire the skills necessary, at the very least, to be somewhat of an asset and not a burden to Matrical.	Find something real and meaningful that I can bring back into my classroom.
Dykstra	My desire for this program is to develop my skills in biotechnology (lab skills, organization of projects, research skills, etc) in order to bring these skills into the classroom with confidence.	I desire to bring advancement to the scientific community through quality research in the field. Ultimately, I want to play a role in the development of new knowledge and/or products that will be useful to the scientific community and the public.	I desire to build a strong connection with area biotech companies and professors so that I will have contacts for wisdom and supplies as I bring biotechnology into my classroom.
Campanella	Gain a better understanding of local biotechnology business.	Be a part of \"real research\" and increase lab \"awareness.\" (Lab awareness to me means to realize what working laboratories do and technologies they use and be able to make my students aware of what scientists really do when they get a job)	Make good contacts with local biotechnology companies and develop a positive relationship between the classroom and the science industry.
Dunlop	Continue to develop my understanding of the skills that are valued/required for students that will potentially be entering the biotech industry.	Continue to develop my own skills as a researcher in the field of biotechnology so I can effectively transfer this knowledge to my students.	Infuse as many of the skills, techniques, process / content knowledge, required in the biotech industry into my classroom.

Each of these teachers accessed many of the BEI resources including BioRad kits, lab materials, CityLab workshops, Reconnect Workshops, and funds for conferences and/or field trips. All participated in the minigrant program to purchase equipment and/or lab materials for their classrooms. None, however, were able to infusehigher level inquiry activities in their classroom, especially compared to the Focus Teacher; and their student scores overall related to interest in science activities and careers were not significantly different than the combined averages of all students. It should be noted that one teacher who is very creative and infused inquiry activities into his classroom following both Phase One and Phase Two (Dykstra) took a teaching job in a very small private school out of the area immediately following the Phase Three experience. Even though he continued to access BEI lab resources, he was unable to offer any in-depth biotechnology experiences for his students due to lack of school resources and limited administrative support.

The following are statements from one of the three Phase Three teachers immediately following the Phase Three experience that are representative of all four teachers: The number of class periods dedicated to biotechnology in the year before the BEI project by this teacher was "*Few if any, and the experiences we had that could have been related back to the biotechnology field were not*." During the first year (after Phase One participation) the biotech changes in his teaching were "*Increases in awareness but not a real change in my classroom."* After his Phase Two experience, he had "*Intentional integration of many new techniques and ideas as a result of the grant" over approximately 10 class periods."* Following his Phase Three experience, he made "*Another huge leap in my confidence in teaching these concepts. Additional techniques and labs will be added this year. I feel the relevance and importance of getting good people into these fields is paramount now. My goal is to attempt to dedicate the majority of the quarter on topics or labs that are directly relatable to the field of biotechnology. Support materials will be essential to making this a reality, but just being intentional I am sure that I will have a minimum of 20 class periods dedicated to biotechnology and related concepts. I would love the opportunity to teach a class dedicated to this field as an upper level elective class so there would not be tremendous time pressures that I have currently teaching an integrated curriculum..." "This process opened my eyes to how seamlessly our students can be integrated into the field of research. I began to realize the reality of integrating high level, open ended investigations into my science classroom. This was fostered by the materials that were made available to us through the grant process including the pGlo kits and electrophoresis kits. … I believe student use of scientific journals will reach a new level. I will emphasize the importance of traceability in our work … accurate, reproducible, experimentation. … I anticipate a tremendous interest in the skill set and outlook my students have on the field of biotechnology as a culmination of the three summers I have spent with this group."*

Teacher Implementation Results

The schools at which BEI teachers were employed are listed in the table below. They have been categorized by size, urban/rural, and grade level.

TABLE 27: School Classifications

		Frequency	Valid Percent
Valid	Alternative School	4	5.8
	Large Urban High School	25	36.2
	Large Urban Middle School	3	4.3
	Mid-size Urban High School	16	23.2
	Mid-size Urban Middle School	9	13.0
	Private School	6	8.7
	Rural High School	1	1.4
	Small High School	2	2.9
	Small Rural High School	1	1.4
	Small Urban High School	2	2.9
	Total	69	100.0

TABLE 27: School Classifications

		Frequency	Valid Percent
Valid	Alternative School	4	5.8
	Large Urban High School	25	36.2
	Large Urban Middle School	3	4.3
	Mid-size Urban High School	16	23.2
	Mid-size Urban Middle School	9	13.0
	Private School	6	8.7
	Rural High School	1	1.4
	Small High School	2	2.9
	Small Rural High School	1	1.4
	Small Urban High School	2	2.9
	Total	69	100.0

A database of all teachers and their implementation activities was compiled. A score was computed based on the number of activities in which each teacher engaged. The potential activities were:

- Participate in Reconnect Meeting(s)
- Attend Final Workshop
- Utilize the Equipment Loan Program
- Participated in the Minigrant Program (extension year)
- Take Students on Biotech Field Trip(s)
- Participated with Dr. Oliver in WSU Spokane CityLab activities

A total of six points was possible. Means were calculated for each school classification. On average, teachers participated in about 3.5 implementation activities related to BEI. School classification does not appear to have an obvious impact on the types of implementation that teachers engage in.

TABLE 28: Mean Participation in Implementation Activities

School	Mean	N
Alternative School	3.50	4
Large Urban High School	2.96	25
Large Urban Middle School	5.00	3
Mid-size Urban High School	3.20	16
Mid-size Urban Middle School	4.22	9
Private School	3.00	6
Rural High School	4.00	1
Small High School	4.50	2
Small Rural High School	5.00	1
Small Urban High School	5.50	2
Total	3.48	69

One measure of project effectiveness is the extent to which teachers participate in activities, request assistance, or take steps outside of the project to implement biotechnology into the classroom. The grant provided resources to support implementation. Data were available for 88 participants (69 teachers, 19 counselors). Over the course of the project:

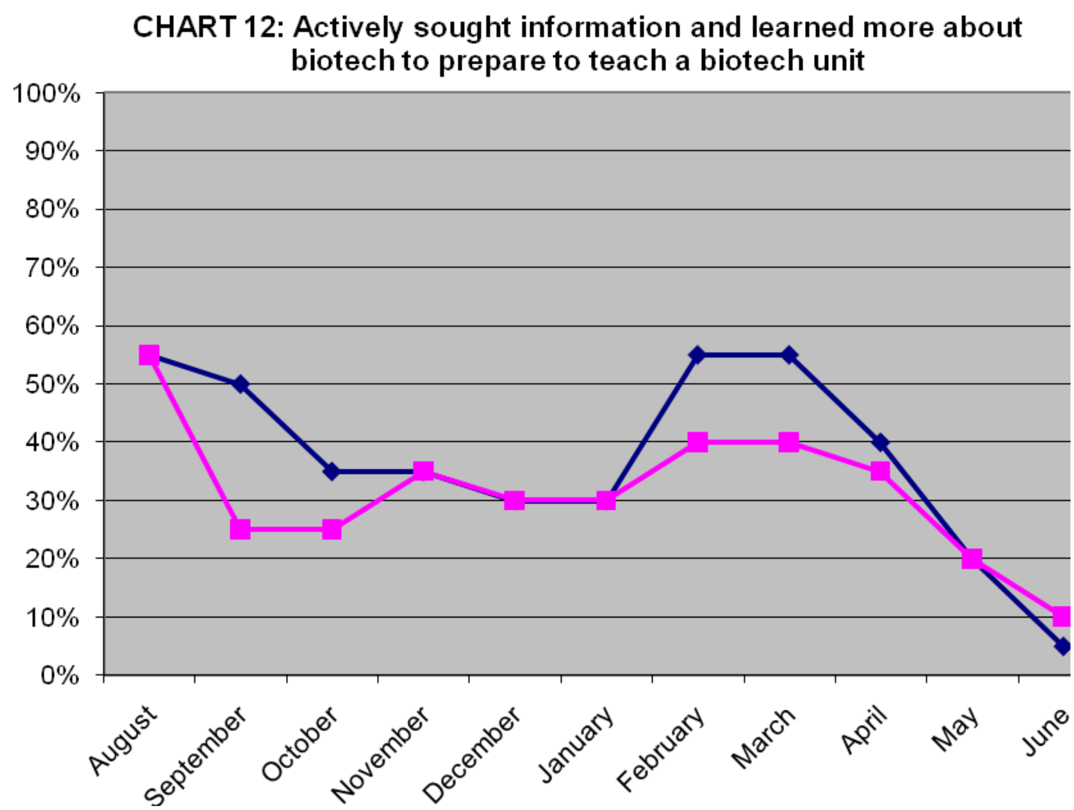
- 49 of 69 teachers (71%) participated in at least one Reconnect Meeting.
- 9 of 19 counselors (47%) participated in at least one Reconnect Meeting.
- 41% of teachers participated in the culminating two-day workshop presented by E. Daugherty.
- 61% of teachers submitted an application and received a minigrant during the extension year.
- 47% of teachers received equipment on loan from WSU's equipment loan program.
- 72% of teacher participants took advantage of the CityLab program.
- 41 of 69 (59%) of teachers received kits for use in their instruction.
- 57 of 69 (83%) of teachers requested and received supplies during the school year for their labs.
- 44% took their students on field trips related to biotechnology.
- Reconnect attendance was highest for those teachers in cohort 1 (76% attended) followed by cohort 3 (68%) and cohort 2 (59%).
- Mini grants were received by a larger percentage of cohort 3 participants (72%) than cohorts 1 and 2 (40% and 64%, respectively).
- Almost twice as many cohort 1 teachers utilized WSU's equipment loan program as did cohort 3 (60% versus 35%, respectively).

The teacher described in the student impact section took advantage of and attended all of the activities and support provided by the project in the service of implementing her research course.

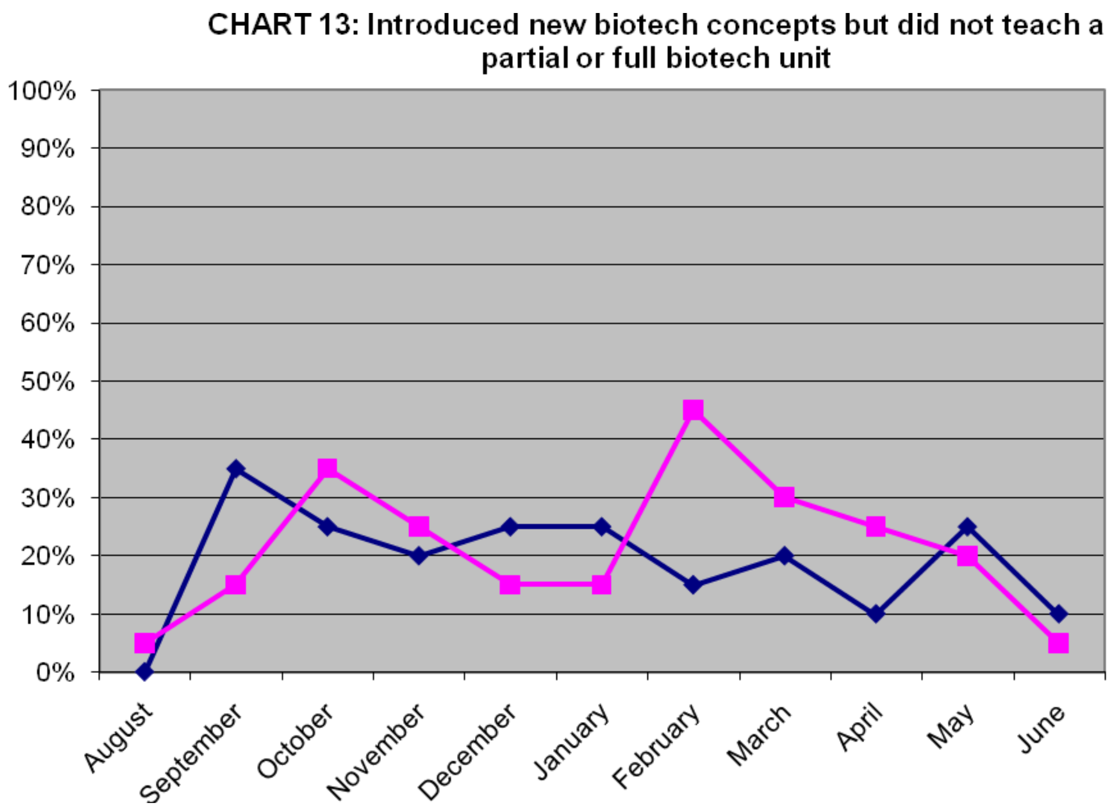
- Of the counselors, 1 out of 19 reported that he/she took students on a field trip related to biotechnology.

Reconnect Meetings Years One and Two Results

During the reconnect meetings, teachers were asked to provide a list of their implementation and classroom integration activities. The following charts depict the percentage of teachers that engaged in specific implementation activities each month as a result of the BEI project. For the chart below, roughly 40% sought out biotech information each month with highs occurring during the first months after summer and winter breaks, and then tapering off at the end of the school year. On all charts, the diamond points and line refers to the 2006-2007 school year; the square refer to the 2007-2008 school year.

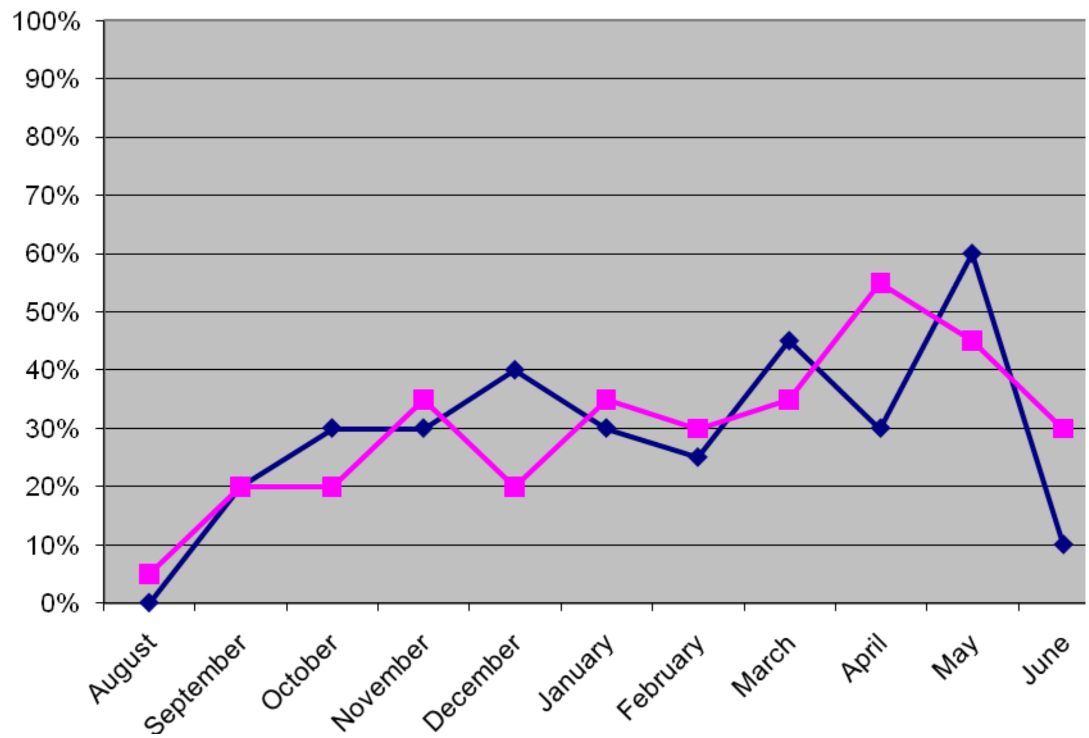


The chart below suggeststeachers introduce biotech topics throughout the schools year, and about a quarter of all teachers discuss biotech with their students on a regular basis.



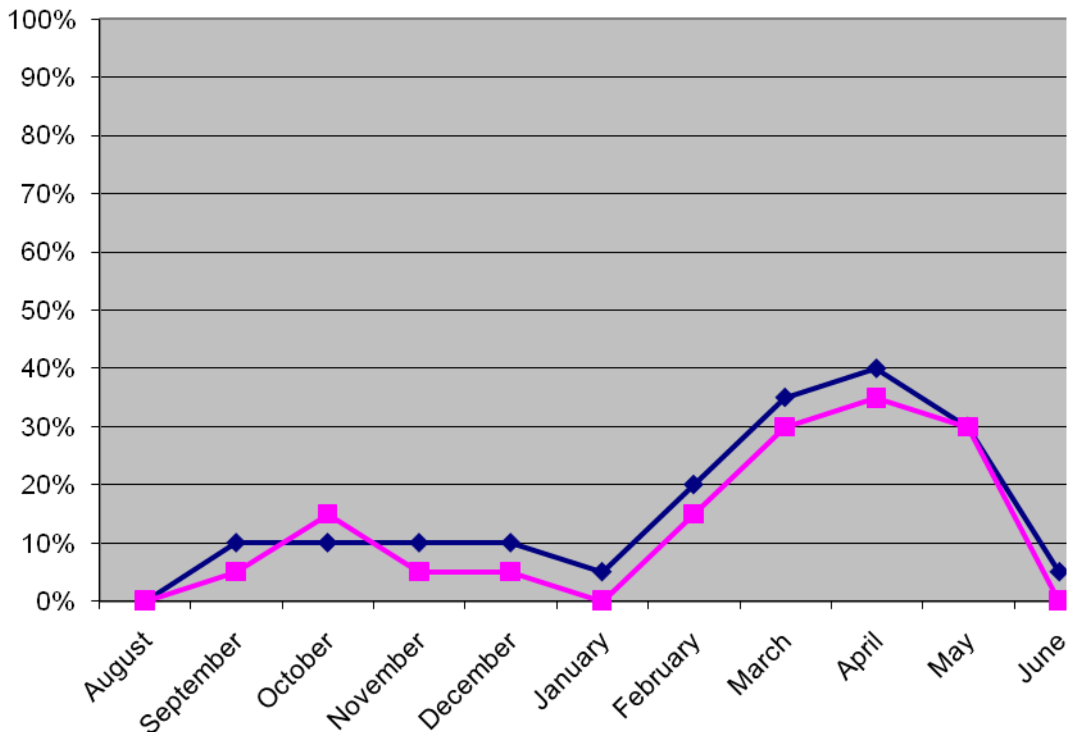
As each year progressed, teachers tended to incorporate 'some biotech concepts or skills into non-biotech lab or classroom activities.' April and May appear to be the months of most intense activity with nearly half of all teachers focusing on biotech instruction during these months.

CHART 14: Incorporated some biotech concepts or skills into non-biotech lab or classroom activities

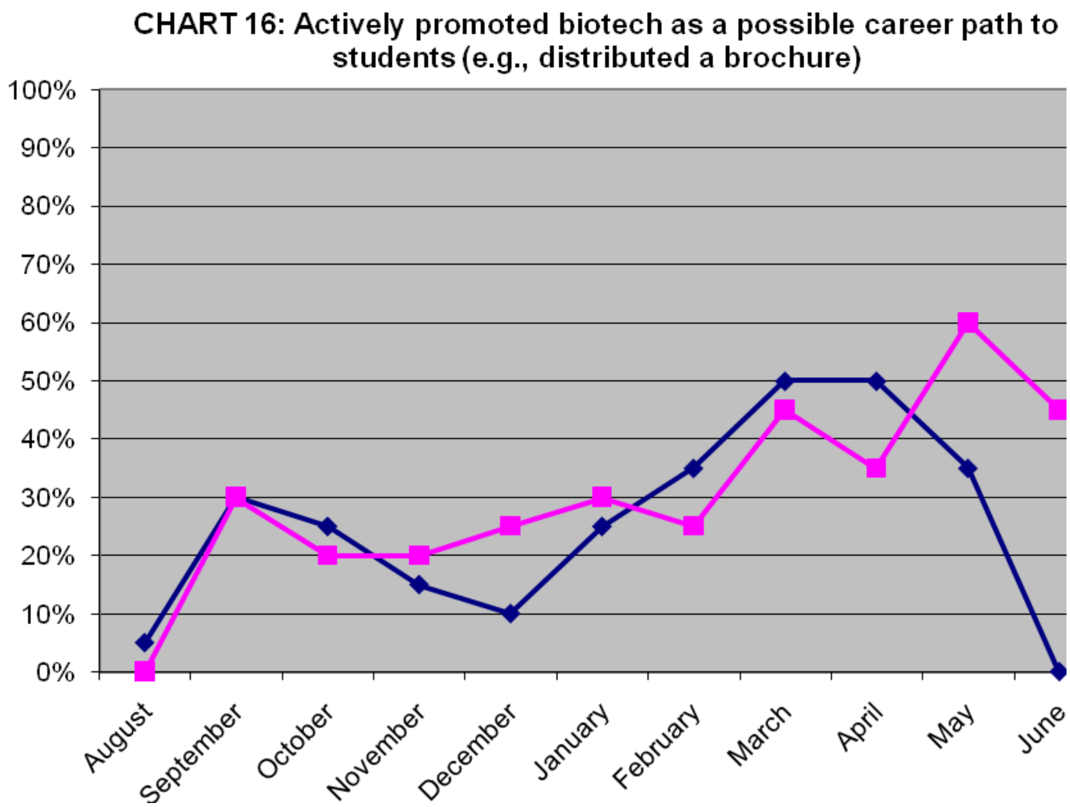


Teaching a full biotech unit was accomplished by the vast majority of teachers (around 30% to 40%) in the later part of the school year. Only one out of 10 reported to having taught a full biotech unit before the month of February.

CHART 15: Fully implemented a biotech unit



After somewhat intense activity in promoting biotech to students after the summer institute, efforts related to this activity dropped until after winter break. Then it appears that teachers made a significant effort to promote biotech to their students. This would be expected, especially for public schools, since genetics and biotechnology are often taught during the spring quarter.



Reconnect Meeting Year Three Results

During the Year Three Reconnect Workshop, teachers were asked to complete a short survey about their implementation activities. An analysis of these data show that:

- Before their participation in the project, teachers reported that, on average, they used .73 kits per year in their teaching. About 65% did not use any kits, about a quarter used 1 or 2 kits per year, and the balance used up to six kits per year.
- During Year Two of the project, the average number of kits used was 1.5. At this time only 20% reported having not used a kit in their teaching. About 62% used 1 or 2 kits in Year Two.
- During the third project year the average number of kits used per teacher was 2.1. At this time there was no change in the percent that did not use a kit, but a larger percentage had used three kits or more during the year.
- Kits used included BioRad pGlo, GMO, ELISA, among others
- Before attending BEI Institutes, participants went to an average of .43 conferences per year. That is, about 73% of teachers that attended the Reconnect did not go to a conference related to biotech or science. However, in Years Two and Three, the mean number of conferences attended had jumped to around .75. Almost two thirds of teachers had attended a conference.
- Before BEI participation, 60% of teachers did not teach their students about biotech careers. By Year Two, only 7% had not taught about biotech careers; and by Year Three this percentage had dropped to 2 percent.
- Stand-alone activities related to biotech were taught by about half of all teachers before participation in BEI. After Year Two, about 90% or more reported doing at least one stand-alone biotech activity with their students.
- Before participating in BEI, the average number of authentic biotech research projects teachers had engaged their students in was .12 with only 6% reported doing so. By Years Two and Three, about a third of teachers said they had done a research project with their students.
- Only 12% of teachers reported they had used the equipment loan program before BEI. After BEI, this had jumped to about half of all teacher participants.

Teacher Follow-Up Calls

The evaluator attempted to contact all participants by phone and through e-mail. The evaluator asked each educator questions about their experience in the project and to what extent they implemented biotechnology into their role as either a teacher or counselor.

Teachers who participated in the project were asked the following questions:

1) What things have you done differently in your classroom as a result of your participation in the BEI project?

2) What kind of support did you request from BEI staff after the summer institute, if any?

3) What impact has your participation in this project had on your students?

If the teachers participated in Phase 2 of the BEI project, then they were asked a fourth question:

4) Did you participate in Phase 2? If so, would you be willing to contact your students from the project and find out what they are doing now?

Counselors who participated in the project were asked the following questions:

1) In your role as counselor, what things have you done differently as a result of your participation in the BEI project?

2) What kind of support did you request from BEI staff after the summer institute, if any?

3) What impact has your participation in this project had on the students that you work with?

The evaluator successfully contacted 61 out of the 88 BEI project participants (≈ 69%)*. Participation ranged from "not implementing any biotechnology content" to "actively attempting to add biotechnology content/programs in school and collaborating with other teachers to extend the influence of the BEI project". The majority of the participants seemed to have a positive experience with the BEI project, whether or not they were able to make significant changes to their current activities. They appreciated the financial support and available materials, and found Sylvia Oliver, in particular, to be a helpful resource.

Teachers seemed to feel more comfortable with the subject matter and biotechnology related labs as a result of their participation in the project. Many felt encouraged to change existing labs in order to make them more in-depth and hands-on. Several teachers added new labs as a result of their participation in the project. Many teachers felt more comfortable talking with their students about the real-life applications of biotechnology, and were able to give them more information regarding biotechnology related careers. According to the teachers that participated, many students showed an increased interest in the forensic aspect of biotechnology, in particular.

Counselors seemed to feel more comfortable approaching the topic of biotechnology with students. Most felt they could give students more options when talking about biotechnology-related careers, and a few have stayed very active in their attempts to research current opportunities in their area and pass them along to students.

A rating scale was used to classify teachers based on the results of the follow up phone call or email exchange:

0 – No Implementation.

The teacher did not implement anything new as a result of participating in the BEI project.
The counselor was unable to offer any new suggestions to students.

1 – Moderate Implementation.

The teacher implemented some new concepts/ideas/labs/teaching strategies etc. relating to biotechnology as a result of participation in the BEI project. Or the teacher made some changes to existing activities, making them more in depth or hands on.

After participating in the BEI project, the counselor was more knowledgeable about career options in the field and was able to offer some suggestions for students who came to them with an interest in biotechnology.

2 – Significant Implementation.

The teacher implemented a significant number of new concepts/ideas/labs/teaching strategies etc. relating to biotechnology as a result of participation in the BEI project. Or the teacher made significant changes to existing activities.

As a result of participating in the BEI project, the counselor was able to introduce students to biotechnology and give them a realistic picture of what it involves. The counselor was aware of opportunities related to biotech: internships, post high school programs in their area, careers, etc., and actively encouraged kids to consider/pursue these options.

Overall, educators (teachers and counselors combined) were placed in the following levels:

- Level 0 – 6 educators
- Level 1 – 30 educators
- Level 2 – 25 educators

In other words, about 10% of participants did nothing in terms of implementation after their participation in BEI, about half implemented to a moderate level, and about 40% indicated that they had significantly implemented their knowledge and skills gained from BEI into their educational contexts.

Of the twelve Phase 2 teachers contacted, five (42%) were classified as significant implementers while seven (58%) were classified as moderate implementers. Of the teachers and counselors that only participated in Phase 1, 23 of 61 (38%) implemented moderately while 20 (33%) implemented significantly. Five of the non-implementers were teachers and one was a counselor. Thus, there appears to be an increase in the level of implementation with an increase in the level (or phase) of the program one participates in.

Interestingly, it was found that those teachers who in the end did NOT implement (Level 0) tended to have lower pre and post-Week Two self-assessment means (which dealt with inquiry and biotech skills). In fact, their Week Two post mean was about the same as the Week Two pre surveys for both the Level 1 and 2 implementers. Additionally, the Level 2 implementers had a slightly higher post mean score than the Level 1 implementers. Self-assessments could therefore be a useful guide to predict teacher self-efficacy requiring increased levels of support by professional development educators, especially for Level 0 teachers.