8-3-2007

GK-12: NSF Graduate Teaching Fellows in K-12 Education at the University of Maine

Susan H. Brawley
Principal Investigator; University of Maine, Orono, brawley@maine.edu

Stephen A. Norton
Co-Principal Investigator; University of Maine, Orono, norton@maine.edu

Barbara J. Cole
Co-Principal Investigator; University of Maine, Orono, cole@maine.edu

Michael Vayda
Co-Principal Investigator; University of Maine, Orono

Eric N. Landis
Co-Principal Investigator; University of Maine, Orono, landis@maine.edu

See next page for additional authors

Investigators
Susan H. Brawley, Stephen A. Norton, Barbara J. Cole, Michael Vayda, Eric N. Landis, Susan J. Hunter, and Ruey Yehle

Final Report for Period: 08/2006 - 07/2007
Submitted on: 08/03/2007
Principal Investigator: Brawley, Susan H.
Award ID: 0231642
Organization: University of Maine
Submitted By:

Title:
GK-12: NSF Graduate Teaching Fellows in K-12 Education at the University of Maine

Project Participants

Senior Personnel

Name: Brawley, Susan
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Norton, Stephen
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Cole, Barbara J.
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Hunter, Susan
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Yehle, Ruey
Worked for more than 160 Hours: Yes
Contribution to Project:
Primary Evaluator for Project beginning in August 2003. Also Co-PI (but duties limited to Evaluation and Recommendations for Program Changes based on same). Also Principal of Hampden Academy (one of our target high schools).

Name: Dill, James
Worked for more than 160 Hours: No
Contribution to Project:

Name: Cobb, Robert
Worked for more than 160 Hours: No
Contribution to Project:

Name: Hess, Thomas
Worked for more than 160 Hours: No
Contribution to Project:

Name: Singer, John
Worked for more than 160 Hours: No
Contribution to Project:

Name: Hopper, Cathy
Worked for more than 160 Hours: No

Contribution to Project:

Name: Jellison, Jody
Worked for more than 160 Hours: No
Contribution to Project:

Name: Cashon, Robert
Worked for more than 160 Hours: No
Contribution to Project:

Name: Jacobson, George
Worked for more than 160 Hours: No
Contribution to Project:

Name: Halteman, William
Worked for more than 160 Hours: Yes
Contribution to Project:
William Halteman served on the selection committee for Fellows in 2005. He performs the statistical analysis for our Evaluator (Ruey Yehle).

Name: Kim, Carol
Worked for more than 160 Hours: No
Contribution to Project:
Dr. Kim is head of our zebrafish genetics' lab and an Asst. Prof. She has trained Fellows in use of zebrafish for studies of development and genetics.

Name: Yehle, Ruey
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Landis, Eric
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Name: Campbell, Steven
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Armstrong, Lisa
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Bushmann, Sara
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Cox, Allison

Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Crowe, Kristi
Worked for more than 160 Hours: Yes
Contribution to Project:
Crowe was reappointed for a second year (2004-05).

Name: Fisher, Erin
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Harris, Pameka
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Horton, Brent
Worked for more than 160 Hours: Yes
Contribution to Project:
Horton was reappointed for a second year (2004-05).

Name: Lage, Chris
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Martel, John
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Perkins, Deborah
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Cromley, Shannon
Worked for more than 160 Hours: Yes
Contribution to Project:
NSF GK-12 Fellow

Name: Gerbi, Christopher
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Goss, Heather
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Lee, Kristen
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Long, Jennifer
Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Miller, Kathryn
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Stearns, Leigh
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Waskiewicz, Justin
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Wilson, Kristin
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Muscato, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:
Provost Fellow participating at half time compared to NSF GK-12 Fellows in 2004-05; this is part of our sustainability plan.

Name: Sackmann, Brandon
Worked for more than 160 Hours: Yes
Contribution to Project:
Provost Fellow participating at half time compared to NSF GK-12 Fellows in 2004-05; this is part of our sustainability plan.

Name: Finlayson, Christy
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Leach, Peter
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: McCann, Donald
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Hansen, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Muhlin, Jessica
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Roy, Eric
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Weldon, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Defilippi, Julie
Worked for more than 160 Hours: Yes
Contribution to Project:
University of Maine Provost Fellow, assigned to NSF GK-12 Program for outreach.

Name: Wilke, Nathan
Worked for more than 160 Hours: Yes
Contribution to Project:
University of Maine Provost Fellow assigned to NSF GK-12 project for outreach.

Undergraduate Student

Name: Olund, Joshua
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Sewall, Jason
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Fenderson, Lindsey
Worked for more than 160 Hours: Yes
Contribution to Project:
NSF GK-12 Fellow (undergraduate-senior)

Name: Bolton, Jason
Worked for more than 160 Hours: Yes
Contribution to Project:
NSF GK-12 Fellow

Name: Howell, Caitlin
Worked for more than 160 Hours: Yes
Contribution to Project:
NSF GK-12 Fellow

Name: Veverka, David
Worked for more than 160 Hours: Yes
Contribution to Project:
NSF GK-12 Fellow, called up with his National Guard Unit in January, 2006 and killed in Iraq in May, 2006.

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Sunkhaze Meadows National Wildlife Refug

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

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

Training and Development:
See findings.

Outreach Activities:
The NSF GK-12 project is, by nature, strongly an outreach effort (see activities and findings).

Journal Publications

Calder, B. L., Brawley, S. H. and Bagley, M., "NSF Graduate Teaching Fellows promote food science education in K-12 schools in Maine.", Journal of Food Science Education, p. 58, vol. 2, (2003). Published,

Books or Other One-time Publications

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:
See Activities and Findings files

Contributions to Other Disciplines:
See activities and findings files.

Contributions to Human Resource Development:
See Project Participants file and Addendum to External Examiner's report.

Contributions to Resources for Research and Education:
See External Examiner's report.

Contributions Beyond Science and Engineering:
Please see External Examiner's file and activities.

Conference Proceedings

Categories for which nothing is reported:

Any Book
Any Web/Internet Site
Any Product
Any Conference

National Science Foundation
Graduate Teacher Fellows in K-12 Education
Final Report

Part I. Principal Investigator Report
A. Participants
1) Senior Personnel

Name	Description of position	Length of time on project	Institutional affiliation, position	Contribution statement
Susan Brawley	PI	3 years	University of Maine, faculty	Supervised the entire program. In charge of program coordinator duties, distribution of equiptment, as well as organized Science Camp.
Barbara Cole	Co-PI	3 years	University of Maine, faculty	Assisted in weekly Fellow meetings, in charge of the distribution of equiptment, facilitated aspects of Science Camp.
Susan Hunter	Co-PI	3 years	University of Maine, faculty	Assisted in weekly Fellow meetings, coordinated meeting logistics, facilitated aspects of Science Camp.
Stephen Norton	Co-PI	3 years	University of Maine, faculty	Assisted in weekly Fellow meetings, maintained pH meters, facilitated aspects of Science Camp.
Eric Landis	Co-PI	1 year	University of Maine, faculty	Assisted in weekly Fellow meetings, facilitated aspects of Science Camp.
Michael Vayda	Co-PI	1 year	University of Maine, faculty	Assisted in weekly Fellow meetings, facilitated aspects of Science Camp.
Ruey Yehle	Evaluator	2 years	Hampden Academy, faculty	Responsible for program evaluation (Co-PI, 1 yr).
Steven Campbell	Program Coordinator	1 year	University of Maine, graduate student	Responsible for stockroom organization, assisted PI and Co-PIs.
Christopher Lage	Program Coordinator	0.5 year	University of Maine, graduate student	Responsible for stockroom organization, assisted PI and Co-PIs.
Jessica Muhlin	Program Coordinator	0.5 year	University of Maine, graduate student	Responsible for stockroom organization, assisted PI and Co-PIs.
Kristi Crowe	Program Coordinator	1 year	University of Maine, graduate student	Responsible for stockroom organization, assisted PI and Co-PIs.
Brent Horton	Program Coordinator	1 year	University of Maine, graduate student	Responsible for stockroom organization, assisted PI and Co-PIs.

2) Graduate Students

Name	Year	Major	Research topic	Graduate location and nature of work	Race/ Ethnicity, gender	Status	Degree	Current position	e-mail	Phone
Lisa Armstrong	Ph.D.	Chemistry	Wood chemistry.	University of Maine, degree program	Female	Not graduated	-	Science Teacher	armstronglisa@bellsouth.net	336- 644-8084
Jason Bolton	B.S.	Food and Nutritional Sciences	Shell disease in lobsters.	University of Maine, degree program	Male	Graduated	B.S.	M.S. student	Jason.Bolton@umit.maine.edu	207-233-2569
Sara Bushmann	Ph.D.	Biological Sciences	Chemical attractants for the blueberry maggot fly.	University of Maine, degree program	Female	Not graduated	-	Ph.D. student	Sara.Bushmann@umit.maine.edu	207-374-2886
Allison Cox	M.S.	Biological Sciences	Cacophony and courtship songs in fruit flies.	University of Maine, degree program	Female	Graduated	M.S.	Research Assistant, Jackson Lab	Allison.cox@jax.org	207-288-6000
Shannon Cromley	M.S.	Biological Sciences	Reproductive ecology of sedges.	University of Maine, degree program	Female	Graduated	M.S.	Horticulture specialist	Shannon.Cromley@verizon.net	
Kristi Crowe	Ph.D.	Food and Nutritional Sciences	Chlorine-alternatives for use in wild blueberry processing.	University of Maine, degree program	Female	Graduated	Ph.D.	Food Scientist, *Southern Living*	Kristi_crowe@timeinc.com	
Lindsey Fenderson	B.S.	Wildlife Ecology	Marine ecology.	University of Maine, degree program	Female	Graduated	B.S.	Graduate student, Univ. New Hampshire	l_fenderson@yahoo.com	
Christy Finlayson	Ph.D.	Biological Sciences	Biological controls in agricultural systems.	University of Maine, degree program	Female	Not graduated	-	Graduate student	Christy.finlayson@umit.maine.edu	207-581-2959
Erin Fisher	Ph.D.	Marine Biology	Population dynamics of sea scallops.	University of Maine, degree program	Female	Not graduated	-	Graduate student	Erin.owen@maine.edu	207-581-2573
Christopher Gerbi	Ph.D.	Earth Sciences	Early Paleozoic orogensesis.	University of Maine, degree program	Male	Graduated	Ph.D.	Assistant Professor, University of Maine	Christopher.gerbi@maine.edu	207-581-2153
Heather Goss	M.S.	Earth Sciences	Metal and phosphorus dynamics in watersheds.	University of Maine, degree program	Female	Graduated	M.S.	EPA, management trainee	Heather_goss@hotmail.com	202-564-0876

Jennifer Muscato Hansen	Ph.D.	Marine Biology	Nutrition and fish ecology.	University of Maine, degree program	Female	Graduated	Ph.D.	Consultant, Herring Gut Learning Center	Jennifer.muscato@umit.maine.edu	207-581-3046
Pameka Harris	Ph.D.	Food and Nutritional Sciences	Food science.	University of Maine, degree program	Female	Graduated	Ph.D.	Assistant Professor, North Carolina Central University		
Brent Horton	Ph.D.	Zoology	Paternal care in white-throated sparrows.	University of Maine, degree program	Male	Graduated	Ph.D.	Postdoctoral Fellow, Smithsonian Institution	Brent.Horton@umit.maine.edu	207-827-8274
Caitlin Howell	B.S.	Biological Sciences	Physiology of wood decay fungi.	University of Maine, degree program	Female	Graduated	B.S.	Graduate student	Caitlin.howell@umit.maine.edu	207-581-3032
Christopher Lage	Ph.D.	Biological Sciences	Molecular tools associated with the conservation and management of wildlife and fisheries populations.	University of Maine, degree program	Male	Graduated	Ph.D.	Assistant Professor, University of Maine at Augusta	clage@maine.edu	207-621-3556
Peter Leach	M.S.	Earth Sciences	Underwater prehistoric archaeology.	University of Maine, degree program	Male	Not graduated	-	Graduate student	Peter.leach@umit.maine.edu	
Kristen Lee	M.S.	Earth Sciences	Submerged environments in Saco Bay, Maine.	University of Maine, degree program	Female	Graduated	M.S.	Graduate student, Univ. Washington	kmlee@coastside.net	206-543-8544
Jennifer Long	Ph.D.	Biological Sciences	Cellular and hormonal mechanisms in migratory songbirds	University of Maine, degree program	Female	Graduated	Ph.D.	Assistant Professor, Husson College	Jennifer.long@umit.maine.edu	207-581-2547
John Martel	Ph.D.	Ecology and Enviromental Sciences	Biological controls in agricultural systems.	University of Maine, degree program	Male	Graduated	Ph.D.	Medical Student, University of Vermont	John.martel@uvm.edu	
Donald McCann	Ph.D.	Electrical Engineering	Acoustic wave sensor applications	University of Maine, degree program	Male	Not graduated	-	Graduate student	Donald.mccann@umit.maine.edu	207-581-3067

Kathryn Miller	M.S.	Ecology and Enviromental Sciences	Forest ecosystem ecology.	University of Maine, degree program	Female	Graduated	M.S.		Kathryn.Miller@umit.maine.edu	
Jessica Muhlin	Ph.D.	Marine Biology	Reproductive ecology, algae.	University of Maine, degree program	Female	Graduated	Ph.D.	Research Scientist, Acadia Partners	Jessica.Muhlin@umit.maine.edu	207-581-3495
Joshua Olund	B.S.	Civil Engineering	Civil engineering.	University of Maine, degree program	Male	Graduated	B.S.	Graduate student, Univ. Connecticut	olund@engr.uconn.edu	860-995-5771
Deborah Perkins	M.S.	Zoology	Migrartory birds.	University of Maine, degree program	Female	Graduated	M.S.	Alaska Wilderness Society Program Manager	pourmeariver@gci.net	907-272-9453
Eric Roy	Ph.D.	Oceanography	Trace metal chemistry.	University of Maine, degree program	Male	Not graduated	-	Graduate student	Eric.roy@umit.maine.edu	207-581-4413
Jason Sewall	B.S.	Computer Sciences, Mathematics	Computer science.	University of Maine, degree program	Male	Graduated	B.S.	Graduate student	jasonsewall@gmail.com	919-962-1743
Leigh Stearns	Ph.D.	Earth Sciences	Glaciers, ice sheet dynamics.	University of Maine, degree program	Female	Not graduated	-	Graduate student	Leigh.Stearns@umit.maine.edu	207-581-1491
David Veverka	B.S.	Wildlife Ecology	Behavioral ecology.	University of Maine, degree program	Male	In January, 2006, David, was called up to serve in Iraq with the Maine Army National Guard, B Co. 3/172 Mountain Infantry. Saturday, May 6, 2006, Staff Sergeant Veverka died in a military hospital near Baghdad, following an attack on his convoy.				
Justin Waskiewicz	Ph.D.	Forest Ecosystem Science	Ecology and silviculture of red oak and white pine forest.	University of Maine, degree program	Male	Not graduated	-	Graduate student	Justin.Waskiewicz@umit.maine.edu	207-581-3829
Jennifer Stowe Weldon	Ph.D.	Civil and Environmental Engineering	Arsenic in groundwater and the environment	University of Maine, degree program	Female	Not graduated	-	Graduate student	Jennifer.Stowe@umit.maine.edu	207-581-3401
Kristin Wilson	M.S.	Marine Sciences	Salt marsh ecology.	University of Maine, degree program	Female	Graduated	M.S.	Graduate student	Kristin.Wilson@umit.maine.edu	207-581-1998

3) Organizational Partners

Name of partner school	Demographic, socioeconomic status (median family income)	Description of activities	Number of Fellows (Number of Teachers)	Subject areas and grade levels of Fellow/Teacher pairings
Asa Adams Elementary School	Suburban (36,500)	Developed and instructed novel science and mathematic lesson plans	3 (2)	5^{th} grade science
Beech Hill School	Rural (38,000)	Developed and instructed novel science and mathematic lesson plans.	1 (1)	5^{th} grade science
Brewer High School	Suburban (36,042)	Developed and instructed novel science and mathematic lesson plans	3 (2)	10-12^{th} grade science, AP Environmental Science, AP Biology
Brewer Middle School	Suburban (36,042)	Developed and instructed novel science and mathematic lesson plans	4 (6)	6^{th} Grade
Bristol Consolidated Schools	Rural (36,250)	Developed and instructed novel science and mathematic lesson plans	2 (2)	5^{th} grade science
Bucksport High School	Rural (35,552)	Developed and instructed novel science and mathematic lesson plans	4 (3)	9-10^{th} grade, General Biology, Marine Biology, Chemistry
Bucksport Middle School	Rural (35,552)	Developed and instructed novel science and mathematic lesson plans	6 (6)	5^{th}, 6^{th}, and 8^{th} grade science
Cave Hill School	Rural (38,000)	Developed and instructed novel science and mathematic lesson plans	1 (1)	4^{th} grade science
Dr. Lewis S. Libby School	Suburban (36,000)	Developed and instructed novel science and mathematic lesson plans	8 (4)	1^{st}, 3^{rd}, 4^{th}, 5^{th}, 7^{th} and 8^{th} grade science
George B. Weatherbee School	Suburban (40,000)	Developed and instructed novel science and mathematic lesson plans	2 (1)	4^{th} grade science
Great Salt Bay School	Rural (36,250)	Developed and instructed novel science and mathematic lesson plans	1 (1)	4^{th} grade science
Hampden Academy	Suburban (40,000)	Developed and instructed novel science and mathematic lesson plans	4 (4)	10-12^{th} grade science, General Biology, Chemistry
Hancock Grammar School	Rural (38,000)	Developed and instructed novel science and mathematic lesson plans	3 (2)	5-8^{th} grade science
Helen S. Dunn Elementary School	Rural (36,000)	Developed and instructed novel science and mathematic lesson plans	2 (4)	2^{nd}, 4^{th}, and 5^{th} grade science
Indian Island School	Suburban (21,346)	Developed and instructed novel science and mathematic lesson plans	3 (3)	3^{rd}, 4^{th}, 6^{th}, 7^{th}, and 8^{th} grade science
Lamoine Consolidated School	Rural (38,000)	Developed and instructed novel science and mathematic lesson plans	1 (1)	5^{th} grade science
Leonard Middle School	Suburban (29,192)	Developed and instructed novel science and mathematic lesson plans	2 (3)	8^{th} grade science
Newburgh Elementary School	Rural (40,000)	Developed and instructed novel science and mathematic lesson plans	2 (1)	3^{rd} and 4^{th} grade science
Nobleboro Central School	Rural (36,250)	Developed and instructed novel science and mathematic lesson plans	3 (2)	3-5^{th} grade science

Old Town Elementary School	Suburban (29,192)	Developed and instructed novel science and mathematic lesson plans	5 (6)	3-5th grade science
Old Town High School	Suburban (29,192)	Developed and instructed novel science and mathematic lesson plans	3 (4)	9-12th grade science, AP Biology, General Biology, Anatomy & Physiology, Wildlife Biology, Earth Sciences
Orono High School	Suburban (36,500)	Developed and instructed novel science and mathematic lesson plans	3 (3)	10-12th grade science, Chemistry, AP Biology, General Biology
Reeds Brook Elementary School	Suburban (40,000)	Developed and instructed novel science and mathematic lesson plans	3 (2)	7th and 8th grade science
Samuel L. Wagner School	Suburban (40,000)	Developed and instructed novel science and mathematic lesson plans	2 (1)	8th grade science
South Bristol Elementary School	Rural (36,250)	Developed and instructed novel science and mathematic lesson plans	2 (1)	5 -8th grade science
State Street School	Suburban (36,042)	Developed and instructed novel science and mathematic lesson plans	3 (2)	5th grade science
Surry Elementary School	Rural (38,000)	Developed and instructed novel science and mathematic lesson plans	3 (1)	5th grade science
Veazie Community School	Suburban (36,500)	Developed and instructed novel science and mathematic lesson plans	4 (3)	4-7th grade science
Viola Rand School	Suburban (36,000)	Developed and instructed novel science and mathematic lesson plans	5 (2)	3rd and 4th grade science
Washington Street School	Suburban (36,042)	Developed and instructed novel science and mathematic lesson plans	1 (1)	4th grade science

Evaluation of the University of Maine GK-12 Project

Summative Report

Submitted by Russell Faux, Ed.D.
June 6, 2007

davisSquare
RESEARCH ASSOCIATES

Executive Summary

The following report presents the methods and findings of summative evaluation research activities conducted by Davis Square Research Associates (DSRA) in the spring of 2007 on the effectiveness of the University of Maine GK-12 project. This project supported University of Maine graduate (largely) students in science and engineering as they worked with local K-12 teachers. The project being evaluated in this report ran from 2000 to 2006, with 55 Fellows working with 96 different teachers. The goals of the project included helping teachers meet their responsibilities in Science and Technology within the Maine Learning Results, supporting science and engineering Fellows' chosen studies, improving the Fellows' skills at communicating science content, and strengthening the school-university connection. The current evaluation is based upon data gathered through three separate online surveys of the Fellows, partner teachers, and University of Maine professors who were either the major professors of the Fellows or the advisors of the undergraduate Fellows.

The key findings of the study include:

- Fellows reported, and exhibited to partner teachers and advisors, growth in their skills in teaching and communicating science content
- Fellows reported a heightened awareness of, and commitment to, K-12 science education and science outreach.
- Partner teachers, especially at the elementary level, reported gains in science knowledge and science teaching skills.
- Partner teachers reported that many of the lessons developed in collaboration with Fellows would continue to be implemented.
- Fellows reported that their progress toward degree completion was slowed slightly, but that the benefits of the GK-12 Fellowship for their careers were evident.
- The quality of the university-based research was reported to be unaffected by the GK-12 commitments
- There is ample evidence of the Fellows having made considerable progress in their careers in science and engineering.

Sample & Method

Sample

The overall sampling frame of the study is co-extensive with the three groups of informants for the project, with all members of each of the three groups invited to submit responses to the appropriate survey. Both invitations and follow-up reminders originated from the University, working in conjunction with DSRA. In this section of the report, DSRA presents the findings from those responses to the surveys that describe the participants.

There is considerable complexity in what follows, due to the Fellows having worked in many different disciplines, with many different teachers, over the years of the project. Each Fellow-partner teacher dyad represents a somewhat different instantiation on project workings and outcomes. Thus, one would be incautious to look for a single - readily amenable to description - treatment in the typical sense of an education project. Instead the project under study will be seen to exhibit a great deal of variability, with this variability depending on the match between the Fellow and the partner teacher as they negotiate around what would be most helpful for the students within the context of the Maine educational standards.

CHARACTERISTICS OF FELLOWS

All living[1] Fellows (N=55) responded to the online survey, for a response rate of 100%. During their period of participation in the GK-12 project, the 55 Fellows reported having studied 34 distinct disciplines in the sciences and engineering. There was little concentration of Fellows in any one discipline, with only four Fellows declaring the same discipline as their field of study. On the other hand, there was some overlap, as, for example, 3 cited marine biology, 2 cited marine biology/marine policy, and 1 cited marine science. Rather than keep the reported fields of study separated, these have been combined into single cells, while preserving what the Fellows actually reported.

[1] The original number of Fellows was 56. Fellow David Veverka died in Iraq on May 6, 2006.

Table 1: Fellows Major Areas of Study

Discipline	N	Discipline (con't)	N
Biochemistry	1	Food and Nutrition Science; Food Chemistry/Food Science; Food Science; Food Science and Human Nutrition	5
Biological Oceanography	1	History and Geological Science	1
Biological Sciences; Biology (Marine Biology)	8	Marine Biology	3
Botany; Plant Science	2	Marine Biology/Marine Policy	2
Chemistry	2	Marine Science	1
Civil and Environmental Engineering; Civil Engineering	2	Mathematics	1
		Microbiology	2
Computer Science, also Mathematics	1	Oceanography	2
Earth Sciences; Geological Sciences; Geology	8	Quaternary Science	1
Ecology; Ecology & Environmental Science	3	Wildlife Conservation (MWC) Wildlife Ecology	3
Electrical Engineering	1	Wood Microbiology	1
Entomology	1	Zoology	2

Not all Fellows were graduate students, as stated above, with 11 (20%) having been undergraduates. With regard to the degree program in which the Fellows were enrolled during their GK-12 experience, the following chart provides counts by degree pursued. Note that the number of declared degrees is 59, exceeding the number of Fellows. This is due to four Fellows having been enrolled in dual degree programs.

Table 2: Degrees Sought by Fellows

Degree Pursued	N
B.A.	3
B.S.	8
M.A.	2
M.S.	21
Ph.D.	25
Have you completed your degree?	35 (64%) report having completed their degree.

The DSRA survey also gathered information on where the Fellows were currently living. Thirty-one of the 55 (56%) reported that, as of this writing, they were living in Maine, with 3 living in New Hampshire, 3 in Massachusetts, and the others living in 12 different states and 3 foreign countries.

With regard to those living in Maine, the following chart presents the reported towns in Maine in which respondents are currently living:

Table 3: Maine Residents by Town

Town	N	Town (con't)	N
Bangor	1	Holden	3
Bar Harbor	1	Mariaville	1
Blue Hill	1	Old Town	5
Boothbay	1	Orono	9
Ellsworth	1	Portland	1
Enfield	1	Skowhegan	1
Farmington	1	Smithfield	1
Hampden	1	South Portland	2

For those currently not living in Maine, the declared likelihood of their returning to Maine was reported to be "26-50%" chance of their returning on a four-point Likert scale (Scale: 1=0-25; 2=26-50; 3=51-75; 76-100). The mean response of 2.04 (SD=1.207, significant at p<.05, Kolmogorov-Smirnov, or K-S), was found to be significant, meaning that there is a greater-than-expected level of consensus around the mean value.

<u>CHARACTERISTICS OF PARTNER TEACHERS</u>

In this section of the report, DSRA presents the data from the teacher survey related to general teacher characteristics, without consideration of the effects of participation.

Seventy-five of 94 teachers responded to the survey, for a response rate of 80%. Different teachers, as well as numbers of teachers, participated in different years of the project, and some teachers participated in more than one year. The overall trend in the project over the 2000-2006 period was strong growth after 2000-01 (30% increase), followed by a leveling, and then strong growth again after 2003-04 (42% increase), followed by a leveling in numbers for the last two years. The following table presents the numbers of participants by year.

Table 4: Number of Teacher Participants by Year

In which year(s) of the program did you participate as a Collaborating Teacher?	N
2000-01	16
2001-02	23
2002-03	26
2003-04	45
2004-05	47
2005-06	46

The largest group (44%) of the responding teachers taught in elementary school, and the fewest (20%) taught in high schools. Most of the degrees held by the responding teachers were in education, and, in general, the participating educators were experienced teachers with 7-10 years of experience. Note the finding of significance among elementary and middle school respondents for the question on experience. This means that this group showed significantly little variance in response to the Likert-scale question. The lack of significance for the high school teachers indicates a normal variance (Kolmogorov-Smirnov, or K-S statistic). In addition, there were found to be no significant differences between the three groups in terms of their years of experience (Kruskal-Wallis, or K-W).

Table 5: Numbers of Teachers by Level

What level describes your position as a teacher during the GK-12 program?	N
Elementary school	33
Middle school	27
High school	15

Table 6: Numbers of Teachers by Degree Held

In what field are the degree(s) that you hold?	N
Education	65
Science	25
Other	10

Table 7: Years of Teacher Experience

How many years had you taught before becoming a Collaborating Teacher in the NSF GK-12 program?	M	SD	Value
Elementary school	3.33*	.957	"7-10 years"
Middle school	3.11*	1.192	"7-10 years"
High school	3.13	1.061	"7-10 years"

*Significant at $p<.05$ (K-S); Scale: 1=0-3; 2=4-6; 3=7-10; 4=10+

ADVISING PROFESSORS

The professors surveyed in the DSRA evaluation served as advisors to the GK-12 Fellows. The response rate for this group was 94%, with 33 of 35 responding. The professors offered information on 46 of the 55 Fellows (84%). Among respondents, 21% of respondents (N=7) said that they were a PI or Co-PI for the project. About two-thirds (67%) of the advisors oversaw the graduate work of one Fellow, with 9 professors supervising two Fellows, and 2 professors reporting having served as major professor with 3 Fellows.

Table 8: Advisors by Field of Study

Discipline	N	Discipline (con't)	N
Applied Mathematics	1	Evolutionary Biology	1
Aquaculture Nutrition	1	Food Science	3
Behavioral and Ecological Physiology	1	Forestry	1
Biological Sciences	1	Insect Ecology	1
Cell Biology	1	Marine Biology	2
Chemistry	2	Molecular Virology	1
Civil Engineering	1	Oceanography	2
Earth Science	5	Plant Biology	1
Electrical Engineering	1	Molecular Biology	1
Entomology	2	Plant Systematics and Evolution	1
Environmental Engineering	1	Wildlife Ecology	1

Method

In collaboration with the UMaine project management and other UMaine stakeholders, DSRA developed three extensive online surveys, one each for Fellows, teachers, and advising professors. Many Fellows worked with different teachers, and these Fellows were asked to generalize across these teachers. Likewise, many of the teachers had worked with more than one Fellow, and these teachers were asked to offer generalized ("composite") responses to the questions. Some professors had also worked with more than one Fellow, and these professors completed separate sets of questions for each advisee, with these data then aggregated by DSRA. Many of the questions used Likert scales (generally 4-point, though with an occasional 3-point question), and some used a "retrospective pre-test" model in which respondents are asked to reflect on circumstances prior to participation, then again at the conclusion of participation.

These surveys were designed to answer the following questions:

- What were the short-term effects of participation on the Fellows and teachers?
- What were the longer-term impacts of participation on the Fellows and teachers?
- What were the effects on the curriculum within which the Fellows and teachers collaborated?

All participants were emailed invitations to complete the online survey, with appropriate follow-up emails as needed. These data were downloaded by DSRA into Excel, cleaned, and then exported into SPSS for analysis. The open-ended questions were coded using HyperResearch.

The statistics used included several non-parametric tests (given the use of scale data), including the Kolmogorov-Smirnov and the Wilcoxon. The former is useful for the determination of the extent to which a set of responses resembles a normal distribution. A finding of significance means for the K-S that the distribution of responses is clustered around the mean value to a greater-than-expected extent. The Wilcoxon test was used for determining the significance of pre-post change. When presented with ordinal data with normal distributions, DSRA used parametric tests (e.g., ANOVA) to determine the significance of the data.

One important limitation to this method (discussed in context below) is that there is no way of associating a given response with a given participant, school, grade level, or discipline. The choice not to ask for identifiable information was made out of a project commitment to keep confidential the identities of respondents. However, one implication of this choice is that some patterns of program effectiveness will not be identifiable. For example, it may be that the project was more effective in 5th grade than in 7th, yet the available data will not be amenable to the analyses that would support such a finding.

What the data will show are the broad patterns of effectiveness among Fellows and partner teachers. The data drawn from the Fellows, as a group, will be triangulated by the group data drawn from the teachers and advising professors. This approach will mean that the findings will remain at a somewhat elevated level of generality. While this generality by no means compromises the essential correctness or value of the findings, it does mean that a highly detailed and nuanced picture of the project will not be forthcoming.

Survey Findings

In this section of the report, DSRA presents the findings from the three surveys. The organization of this section is designed around the two target beneficiary groups in the project (Fellows and teachers), with separate sections on outcomes (more or less immediate effects) and impacts (longer-term effects).

FELLOW OUTCOMES

In this section, DSRA presents the findings from the three surveys relative to the Fellow-level outcomes attributable to the Fellows' having participated in the GK-12 project. There are three "witnesses" to these effects, namely, the self-reports of the Fellows themselves, the observations of the teachers, and the observations of the advising professors.

One important restriction (presented at the conclusion to the Method section) to the following is that, due to the promises of confidentiality, there is no practicable way of linking any given participant's observations to any other particular participant. Thus, a regression analysis relying on the identification of the relative contributions of teachers, grade levels, schools, content areas, etc. will not possible. Instead, this report will rely on more global depictions of project effects built on self-reported scale data.

In the following table, Fellows (N=55) report on pre-post gains (using the retrospective pre-test model described above) in five areas important to the project goals. Note that all areas show significant improvement, a very solid and positive finding. Whenever appropriate, both the mean (M) and standard deviation (SD) are presented in the following and in all subsequent tables throughout the report.

Table 9: Fellow Gains

Domain	M/SD: Prior to participation	M/SD: After participation
Written communication	3.07/.690	3.40*/.531
Oral communication	2.53/.663	3.45*/.503
Interpersonal skills	2.89/.685	3.31*/.573
Attendance at scientific meetings	2.36/.847	2.84*/.877
Exposure to an interdisciplinary peer group	2.13/.840	3.18*/.641

*Significant at $p<.05$ (Wilcoxon); Scale: 1=Poor; 2=Fair; 3=Good; 4=Excellent

Fellows attributed the growth cited in Table 9 to various aspects of the project, as Table 10 shows below. The attributions of the gains were especially strong in the areas of oral communication and exposure to an interdisciplinary peer group, a finding that will find further support below. On a four-point Likert scale, the Fellows reported that participation had steady and positive effects in the following areas.

Table 10: Fellow Attribution of Growth to Participation

Item	M/SD	Value
Written communication	1.98*/.733	"A little"
Oral communication	2.91*/.674	"Quite a bit"
Interpersonal skills	2.38*/.805	"A little"
Attendance at scientific meetings	2.24*/.922	"A little"
Exposure to an interdisciplinary peer group	2.82*/.819	"Quite a bit"

*Significant at $p<.05$ (K-S); Scale: 1=None; 2=A little; 3=Quite a bit; 4=All or nearly all

The Fellow survey asked respondents whether their views on science had changed through participation, and to what extent various features of participation contributed to the change in their views. Fellows responded that, indeed, their views had been changed "to some extent," with the most influential aspect of the project being the requirement to prepare materials in areas outside their university studies.

Table 11: Fellows Change and Attributions

Item	M/SD	Value
To what extent was your knowledge of science increased through your participation in the program?	3.27*/.706	"To some extent"
[Through] lectures/activities during science camp	2.60*/.760	"To some extent"
[Through] preparing material in my own field	3.02*/.913	"To some extent"
[Through] preparing material in fields outside my own	3.42*/.832	"To some extent"
[Through] the weekly seminar	2.11*/.832	"Maybe a little"

*Significant at $p<.05$ (K-S); Scale: 1=None; 2=Maybe a little; 3=To some extent; 4=A great deal

The following table shows the respondents' ratings of themselves (using the retrospective pre-test model) in various domains relevant to the project. Note that the post-test gains are consistently significant, yet another very compelling indicator of the consistent and overall effectiveness of project participation. It is also interesting to see that even as the Fellows were reported learning new science through the project (see previous table), they also reported strong gains in their understanding of scientific concepts. The oft-cited claim that teaching concepts can assist in the teacher's better grasp of the concept appears to hold true in the case of the UMaine Fellows.

Table 12: Fellow Pre-Post Changes

Item	M/SD: PRIOR to participation	M/SD: AFTER participation
Your awareness of the challenges of teaching	2.24/.816	3.71*/.497
Your understandings of scientific concepts	3.16/.570	3.62*/.490
Your perspectives about science	2.96/.607	3.47*/.539
Your communication skills	2.67.668	3.47*/.573
Your teaching skills	2.33/.840	3.45*/.538
Your ability to explain your research	2.42/.712	3.45*/.571
Your interest in participating in outreach	2.40/.710	3.38*/.652
Your ability to develop curriculum materials	1.98/.871	3.36*/.589
Your self confidence	2.56/.714	3.31*/.573
Your ability to conduct research	2.93/.716	3.24*/.607
Your time management skills	2.45/.765	3.13*/.747

*Significant at $p<.05$ (Wilcoxon); Scale: 1=Poor; 2=Fair; 3=Good; 4=Excellent

When asked the more general question on their appreciation for science education (*How has your appreciation for science education changed?*), Fellows rated themselves as having changed from a mean of 2.75 ("A good appreciation") to a 3.80 ("A strong appreciation"), a finding significant at $p<.05$ (Wilcoxon). This finding is clearly consistent with the previous presented findings of participation having been of great benefit for the Fellows, with the only possible cost being a slightly extended time in finishing their degrees (see section on Fellow impacts below).

Fellows were asked two open-ended questions regarding the influences that the GK-12 project had on the Fellows' teaching skills. Responses to the first question (*In what ways did the fellowship influence your ability to teach? If you also worked as a TA and/or received other sorts of preparation for teaching, please compare the impacts of the NSF GK-12 program to these other experiences)* varied from generally positive (though not always) observations on the life of a teacher to other, more positive opinions on teaching and outreach at the university level.

The following is a sample of what the Fellows reported:

Table 13: Fellow Views on Teaching

Responses Regarding K-12 Teaching	Responses Regarding University Teaching
• I became much more aware of the challenges and time involved in curriculum preparation as a result of the fellowship. • My fellowship experience made me realize how much I enjoy working with younger kids (elementary school age). It is a great age for doing lots of 'hands on' learning. • Although I would like to work in the science classroom in some capacity, I also learned that I could never do what these teachers are required to do on a daily basis. I gained tremendous respect for the teachers I worked with, two in particular. • I now see science education in much broader terms. I used to simply think of undergraduate education, or maybe high school. I now understand the importance and indeed the critical nature of science education for all age groups. • I enjoyed the teaching. I DID NOT LIKE the bureaucracy, the general inability of teachers to control their classes, and the hurdles I would have to clear (certification, fingerprinting etc.) to take a relatively low paying job. • I found working with children to be extremely fulfilling. Working solely in academia or industry with peers will not satisfy my long-term career goals. Participating in the NSF GK-12 program made me realize this; perhaps teaching high school or at a community college will be in my future.	• I am more interested in a position where I can focus on teaching. • I now see science education as being of paramount importance - more important than even research itself. My intended career path has shifted to accommodate that opinion - I seek an eventual appointment that will place appropriate emphasis on education. • The experience strengthened my overall interest in teaching. However, I became less interested in teaching grades K-12 and more certain that I wanted to teach at the college level. • Though I gained valuable experience from teaching elementary school students, this program reinforced my interest in teaching at the university level. • Prior to my participation in the program, my career goals focused primarily on university academics. I am now pursuing jobs that are either strictly science education or marine policy with a strong outreach component. Although other factors have influenced this shift, it is in large part due to my participation in the GK-12 program. • I ended up becoming a professor focusing on undergraduate education because of the enthusiasm of teaching I discovered through this program. I am where I am in no small measure because of the NSF GK-12 program, without a doubt. • I always knew I wanted to teach university-level classes. This broadened my idea of what 'teaching' means. The GK-12 fellowship gave me the chance to teach to include a diverse class as opposed to only teaching to inspire a class of biology majors. I am interested in pursuing this type of teaching by teaching a Freshman Seminar, for instance.

Fellows were also asked an open-ended question on the effects of participation on their post-secondary teaching (*Can you identify any aspects of your NSF GK-12 experience that influenced your college-level teaching? Please explain*). Overall, Fellows expressed the opinion that working with younger audiences had been useful in helping them to communicate science content more effectively. The responses to the question can be split into two groups: one that speaks of the generic improvement of teaching and communication skills, and a second group that is more rooted in college-level work. In both cases, however, Fellows were nearly unanimous in declaring having received great benefit from their work as Fellows.

Table 14: Fellow Changes in Views on College-Level Teaching

Responses Regarding K-12 Teaching	Responses Regarding University Teaching
• There is no question that the GK-12 program is the reason for my improved communication among non-scientists. • I am now able to explain my work to my parents (high school educated), and friends from back home (many are not high school educated). • The GK-12 program helped me prepare lessons and work on my communication skills while in the classroom. It takes a lot of practice and skill to be able to lead discussions and ask 'the right' questions of students. • This fellowship greatly increased my ability to speak clearly and concisely in front of a group, which has always been a challenge for me. It also taught me how to teach concepts from different angles in order to reach students at all learning levels, and how to present things so that the students are encouraged to think and discover for themselves. • I am much better at communicating scientific principles and details to a broader audience in a manner that all can understand. • I got a much better sense of what 6th graders are like - where their learning is, what engages them, what interests them, what they need to learn. This knowledge has proved very valuable data point to me as I work with students of all ages. • I am a far better teacher now. After preparing lessons for 4th graders, I can now express a concept with far greater clarity than I used to.	• I had worked for several years as a TA before getting the NSF fellowship. The fellowship was a much better teaching experience than being a TA, because I could design my own lectures and laboratory activities. • As a senior medical student I am now responsible for teaching the first years as well as my patients. The ability to verbalize concepts to a varied population (i.e., scientist, children, parents, care-takers) was a skill I developed through my experiences in the NSF program. Invaluable. • I think it would have taken 2-3 years of 'TAing' to learn the lessons that I did as a GK-12 fellow. This provided me with a real boost over other TAs and in only my 2nd year of 'TAing' I won a departmental-wide award for excellence in teaching introductory classes. That award reflects as much on my NSF GK-12 training as it does on my Wisconsin experiences because although it was in graduate school that I developed and honed my teaching techniques as they exist now, it was my frankly bittersweet experiences in UMaine's GK-12 program that prompted me to look for ways to improve myself both as a student and as a teacher. • I believe fellowship helped me be more prepared for my later experience as a UMaine TA. Teaching elementary school students improved my communications skills. My experience as a GK-12 fellow improved my ability to prepare for and organize college level lab and fieldwork for the Semester-by-the-Sea undergraduate program. • I learned to tailor the information to the target audience. Learned how to explain concepts in many different ways. The NSF program also made me a much more effective TA through planning lessons and communication skills.

The Fellows were asked two additional three-point Likert scale questions regarding the levels of support they received from partner teachers and advising professors. In both cases, the Fellows reported strong levels of support, with both cases achieving statistical significance, indicating that the support for the Fellows was strong, widespread, and long lasting over the years of the project.

Table 15: Fellows Reports of Support

Item	M/SD
What best describes the reaction of your major professor (or advisor) to your participation in the NSF GK-12 program?	2.65*/.517
Overall, what best describes your collaborating teachers' quality of participation with you during the program?	2.87*/.433

*Significant at $p<.05$ (K-S); Scale: 1=Unenthusiastic, negative; 2= Neutral; 3=Enthusiastic and supportive/helpful

OBSERVATIONS FROM PARTNER TEACHERS

The collaborating teachers confirmed the Fellows' self-report in their survey. While the questions vary somewhat from the questions directed at the Fellows, the teachers' responses (to the four-point scale questions) also exhibit statistically significant changes across the three areas central to project goals.

Table 16: Teacher Reports of Fellow Change

How would your rate your Fellow's improvements during the period of your collaboration in the following areas?	**M/SD: At the Beginning**	**M/SD: By the End**
Teaching	2.65/.726	3.48*/.601
Communication	2.79/.684	3.52*/.554
Role model of a scientist	3.40/.658	3.73*/.528

*Significant pre-post at $p<.05$ (Wilcoxon); Scale: 1=Poor; 2=Fair; 3=Good; 4=Excellent

OBSERVATIONS FROM ADVISING PROFESSORS

The following tables present the data from the advising professors. These data were collected somewhat differently as the professors did separate sets of questions for each advisee (unlike the teachers). These data were then aggregated by DSRA for the summative analyses below. The advisor-Fellow relationship doubtless encompassed many aspects of the Fellow's overall graduate experience, with some advisors more closely attuned to some or all aspects of the GK-12 experience than others.

The findings of significance for the items in Table 17 mean that the respondents' answers varied significantly from a normal distribution of responses, in other words, there was a high degree of consensus around the mean value.

Table 17: Professor Reports of Advisee Change

Item	M/SD (N=42)	Value
1. How much did your advisee's oral communication improve, in your judgment, as a result of tenure as a NSF GK-12 Fellow?	1.95*/.582	"Somewhat"
2. How much did your advisee's teaching skills improve, in your judgment, as a result of tenure as a NSF GK-12 Fellow?	2.57*/.590	"A great deal"
3. How did the NSF GK-12 fellowship affect the time required for your advisee to complete his/her degree?	1.60*/.701	"No effect"
4. How did the NSF GK-12 fellowship affect the quality of your advisee's research for the degree?	1.90*/.532	"No effect"
5. Did the NSF GK-12 program change your advisee's career goals [with regard to research]?	1.90*/.484	"No effect"
6. Did the NSF GK-12 program change your advisee's career goals [with regard to teaching]?	2.45*/.504	"No effect"

Significant at p<.05 (K-S)
Scale Q1 & Q2: 1=Not at all; 2=Somewhat; 3=A great deal
Scale Q3: 1=It took longer to complete; 2=No effect; 3=It enabled faster completion; 4=It enabled faster completion
Scale Q4: 1=Poorer quality; 2=No effect; 3=higher quality
Scale Q5 & Q6: 1=Less interest; 2=No effect; 3=More interest

The following tables present a sampling of the professors' open-ended responses relevant to their assessments of the Fellows' improvements in communication and teaching. Note the consistently positive comments on the Fellows' development, even when the Fellow began participation at an already high level (thus risking a possible ceiling effect). Note also that the professors identify specific areas that cannot reasonably be attributed to simple maturation.

Table 18: Professor Comments of Fellow Communication Skills

Communication Skills
• He was quite good to begin with, but the experience certainly helped him put difficult topics into an explanation framework for non-scientists. • She became more relaxed in front of an audience/class. • Ability to give oral presentations was greatly improved, one-on-one communication not so much. • I did not notice a dramatic change in communication, but there was improvement. • This student became more relaxed and at ease when making presentations before peers and faculty • This was his first experience in trying to convey what he knew well to a group of students with less training, less understanding, and less capability. He learned to communicate at many levels. • This student had already developed strong communication skills from previous teaching and research experiences. • He had good skills, but they certainly improved as a result of this program

Table 19: Professor Comments on Fellow Teaching Skills

Teaching Skills
• He was already a good teacher, but he learned a lot about the ability of very young students to do real experiments with controls and replication, and to think of all the needed controls with his help.
• My advisee started out with a strong commitment to teaching. This program helped develop specific teaching skills.
• She learned to deal with the same material at different intellectual levels.
• The fellowship gave her new approaches in teaching to try and exposure to many excellent teachers in the PIs and other fellows.
• [THE FELLOW] devised many excellent, hands-on activities for levels of students from 3rd-12th grade. A lot of them were ones in which the students participated in real science, and even contributed data in a few cases to papers that are being published. She learned to pace, how to inject humor, how to keep a group of learners engaged. She is now an excellent teacher.
• As an undergraduate fellow there was less classroom responsibility but the exposure to classroom teaching was valuable.
• This student benefited from working with teachers in developing lesson plans that meshed with state content standards - provided a new perspective in how GK-12 education is structured and how university level research can be incorporated into education at other levels.
• He learned how to develop lessons plans. What types of experiments will work with students of different ages.

FELLOW IMPACTS

In this section of the report, DSRA presents data and findings relevant to those project effects that "ripple out" in the Fellows' careers beyond the immediate experience of project participation.

When asked if participation had delayed their progress toward the completion of their program ("To what extent would you say that your participation in the NSF GK-12 program affected your progress toward your degree?"), Fellows, on average, said that it had delayed them by one semester ($p<.05$, K-S). The attributed delaying effect of participation may have been offset to some degree by the stipend received by the Fellows. When asked about the importance of the stipend ("How important was receipt of the GK-12 stipend to completion of your graduate degree?"), Fellows, on average, reported its having been "very important" ($p<.05$, K-S).

In terms of the Fellows' progress and the quality of the Fellows' work at UMaine, it may be worth recalling the above data (Table 17) from the advising professors who tended to see participation as possibly slowing the progress of the Fellows (generally confirming what the Fellows report), without, however, exercising any effect on the quality of the Fellows' research.

CAREER IMPACTS OF PARTICIPATION

Given the importance of teaching in the GK-12 fellowship, one might expect there to have been some effect on the Fellows, either positive or negative, regarding their attitudes toward teaching, and, in particular, the place that teaching may assume in their careers. When asked questions about this impact of participation, Fellows said that they were now moderately more interested in teaching. The following table presents these data, along with the numbers of Fellows who have since taught undergraduates.

Table 20: Fellow Reports of Participation Career Impacts

Item	M/SD
To what extent did your participation in the NSF-GK-12 influence your interest in teaching as part of your career?	4.05*/.931
Have you taught undergraduates after completing your fellowship?	30:Yes 25: No

Significant @ $p<.05$ (K-S); Scale: 1= Greatly diminished my interest; 2=Moderately diminished my interest; 3= Neither diminished nor heightened my interest; 4= Moderately heightened my interest; 5= Greatly heightened my interest

When asked if the fellowship had affected their career choices (*How did the fellowship affect the direction of your career?*), the Fellows reported, "It modified the field of science I pursued," with this finding being significant (M/SD=3.30/.986, $p<.05$, K-S, with the scale for this question being 1=It changed my career direction to one outside of science; 2=No effect; 3=It modified the field of science I pursued; 4=It strengthened my original career goals in science/technology/engineering). Combining these various data, one would reasonably conclude that the Fellows, as a group, remain firm in their disciplinary allegiances, yet now see teaching as a an integral part of, rather than extraneous to, their envisioned professional lives.

The following table presents additional relevant data that confirm the previous finding. Fellows report increased levels of activity they describe as "dissemination," especially in the K-12 education space. This finding is suggestive of there being a longer-term commitment to K-12 educational outreach, a development one would be fairly confident in associating with participation in the GK-12 project.

Table 21: Fellow Changes in Outreach Activities

Please compare your public outreach (efforts to more broadly disseminate science learning) before and after your tenure as a NSF GK-12 Fellow	**M/SD: PRIOR to participation**	**M/SD: AFTER participation**
Museums	1.62/.871	1.73/.891
Clubs/service organizations	1.98/.892	2.53*/.997
K-12 classes	1.60/.894	2.56*/.856
Other	1.47/.663	1.75*/.966

*Significant at $p<.05$ (Wilcoxon); Scale: 1=None; 2=Some; 3=Regular, but not frequent; 4=Frequent

OVERALL FELLOW EFFECTS OF PARTICIPATION

- I feel this program was a winner to each stakeholder in the program. Everyone benefited from participation- the teachers gained confidence in subject matter, access to otherwise expensive materials. Students gained a mentor/role model, enthusiasm for science, and an opportunity to go on field trips, and the fellow gained experience teaching. For myself, this was the only opportunity in my graduate career to teach and develop a teaching philosophy. The only negative effect is that it limited time to focus on my dissertation, delaying publications. However, I would not give up the opportunity to be a Fellow if the chance came again.
- As a direct result of the NSF teaching fellowship, I have become a much more effective teacher, and I am better able to communicate my research to a broader audience. This has enhanced my career in many ways, from writing better grants to being more confident in academic interviews.
- I feel that this is a wonderful program and has greatly benefited the fellows, participating teachers, students and schools. Although, this program is ending, it has established an excellent foundation upon which participating teachers are building to enhance science education in their schools. The program has also opened the lines of communication between the local teachers and the University.
- Positive all around -- without question.
- The relationships built during this program were unbelievable. The students remembered what I taught them many years later. I would see students randomly throughout the State of Maine and they would always come up to me and say the nicest things. I think that the K-12 students and graduate fellows got a lot out of this program in terms of being able to talk about science to a completely different audience.
- I entered this program as a person training to be a college biology teacher. Because of my experiences here I question that goal at times. Now I can't help but wonder if a scientist passionate about science education shouldn't be teaching preschool and kindergarten. If I really want to spark a love of

science and life, I tend to think I'll be more effective with younger children than college students.

- I have written a piece about this before although can't remember where that ended up. I don't have time now, but would always be willing to talk at more length with anyone. I can't say enough good things about the program. I loved it and thought it was one of the best things that ever happened to me, both in my career and for personal growth.
- The fellowship was an incredible experience for all who participated, and I am disappointed that the program no longer has funding. I also want to acknowledge the principal investigators' brilliance, especially Susan Brawley--they served as positive role models for aspiring scientists.

Fellows were also asked about the value of the fellowship experience in seeking new employment [*"Did the NSF GK-12 Fellowship help you obtain your present position (e.g., did your current employer etc. comment favorably upon this part of your resume)?"*]. Most Fellows (56%) said that it had, with the following a sampling of what the Fellows said to expand upon their answer:

- Even though the NSF program is 6 years past in my resume, I have had interviewers as recent as one month ago inquire about the experience. Discussing the teaching and research of the program helps to explain the career path I have chosen and my strengths within it.
- Yes, I believe so. I am currently working at an institution that makes teaching a priority, and the interviewing committee was very impressed with my extensive teaching experience, particularly the NSF GK-12 program. I also think the experience helped me to get on several other short-lists for liberal arts college jobs.
- I feel the program helped me in grant writing, which has provided necessary support for me to finish my degree.
- There is no question that my NSF Fellowship played a large role in my obtaining my current position. No question.
- I would say the NSF Fellowship played a role in my acceptance to medical school.
- The hiring panel was very impressed by my academic achievements and my standing put me in front of several applicants for this position.
- I recently had my first academic interview for an assistant professor position. The program not only gave me more confidence in my abilities, but many professors interviewing me were impressed with my involvement in the program. I feel that the fellowship will give me an edge in getting a job in my field.
- I worked as an exhibit designer and content specialist for a new science education center at a marine laboratory. I worked in this position for 4 years after graduate school. It was a highly competitive position, with 100+ people applying for it, and later I was told that 2 -3 main factors helped me get hired, one being my work as an NSF fellow. In addition, the

> program director provided a recommendation for me that helped in my application process.

Two additional points need to be mentioned. Fellows were asked about the time it took to complete their degree program. Some of these data suggested that the Fellows might have misunderstood the question to refer to the time it took from the time of the Fellowship to finish. These data do not appear here, though in Appendix 2 one can see a summary of the responses to the question on this point.

A second difficulty arose when Fellows were asked about their current sector of employment. An unreasonably high number reported that they were looking for work. For this question, as well as the question on the time spent in their degree programs, the Fellows have since been re-surveyed. As soon as these data are available, they will be provided as an addendum.

Finally, the Fellows were asked to submit a list of publications and awards (see Appendix 1 at the conclusion of this report). Though these may not be directly attributable to, or limited by, project participation, it is nevertheless clear that the Fellows have been highly active in ongoing research and presentations. Fellows cited 134 presentations and papers across a wide range of content areas, along with 24 awards. Considering their striking success in academia, along with their commitments to science outreach, the Fellows may be collectively regarded as a new kind of scientist, one who is equally at home in creating and communicating new knowledge.

PARTNER TEACHER OUTCOMES

In this part of the report, DSRA presents the evidence for changes in partner teachers attributable to participation in the GK-12 project. The sources for the data are the teachers themselves and the Fellows. As with the previous section, the data cannot be linked from one specific person to another, but rather they present general patterns that present a synthetic picture of project effects.

Rather distinct from standard professional development projects, The GK-12 project allows individual teachers to work in a more or less unfettered manner to strengthen the teaching and learning of science. This being the case, individual teachers are encouraged to express needs and interests that can be supported by the Fellows. Consequently, considerable variation develops from GK-12 dyad to dyad, with the resultant set of outcomes often resistant to the deployment of common measures.

In the following section DSRA presents what the teachers (75/94 reporting, for a response rate of 80%) self-reported regarding the effects of participation.

PARTNER TEACHER REPORTS

The first table on teacher effects presents the data from a series of six retrospective pre-test questions regarding areas central to project goals for teacher change. Note that in all areas the teachers reported statistically significant gains in knowledge and attitude.

Table 22: Teacher Self-Reported Growth

How would you rate yourself in the following areas?	**M/SD: Prior to participation**	**M/SD: After participation**
Knowledge of current science	2.68/.619	3.21*/.473
Attitude toward scientific research	2.79/.703	3.53*/.528
Belief in students' ability to do complex science	2.68/.661	3.32*/.524
Confidence in teaching cutting edge science	2.32/.791	2.95*/.590
Attitude toward the GK-12 program	2.96/.603	3.55*/.722
Attitude toward university partnerships	2.79/.793	3.51*/.705

*Significant at *p*<.05 (Wilcoxon); Scale: 1=Poor; 2=Fair; 3=Good; 4=Excellent

The data gathered from the Fellows confirm with a significant degree of consensus that the teachers grew in science knowledge and teaching skills. Many Fellows worked with more than one teacher, and thus the Fellows' responses refer to a composite picture, the representativeness of which cannot be determined. Nevertheless, the overall patterns are clear and positive.

Table 23: Fellow Reports of Teacher Growth

Item	**M/SD**	**Value**
Changes in partner teacher's knowledge	3.15*/.678	"Fairly good"
Implementation of lessons	3.00*/.694	"Fairly good"
Effects on the partner teacher's other lessons	2.60*/.830	"Fairly good"
Extent of dissemination through the school	2.58*/.875	"Fairly good"
Extent of dissemination beyond the school	2.24*/.942	"Some, but not much"

*Significant at *p*<.05 (K-S); Scale: 1=Little or none; 2=Some. But not much; 3=Fairly good; 4=Excellent

When asked to expand on their observations of teacher change, the Fellows asserted that there was some variability among the teachers, with some more receptive and eager to incorporate innovation than others. The following is a sample of what the Fellows reported:

- I had different levels of participation among the different teachers. Two of the teachers were fantastic and incorporated my lessons into the direction of the science class. One teacher treated my lessons as stand-alone, and because of this it was very difficult to get anything done.
- It is hard to answer this question because over the years I was a fellow, I had over 5 cooperating teachers, and each was unique. So it is hard to 'lump' them into one section. On the whole, my cooperating teachers were enthusiastic and definitely took advantage of the opportunities that came with the program.
- The teachers were excited about a lot of the lessons and material I brought in. However, they were constrained by the 'teach to the test' paradigm that the US educational system currently requires.
- It really varied with the teacher, but I feel the teachers who didn't have a strong background in science [were the ones who] benefited the most. For them, I think they enjoyed the availability of new equipment (e.g. dissecting and compound microscopes) and the new ideas/activities I brought to the classroom.

A related goal of the project was to assist teachers in developing a more global comprehension of the entire science curriculum. In this effort the project realized solid success, with teachers consistently (note the significance of the mean values) reporting that their understanding was "somewhat improved" (2 on a 3-point scale).

Table 24: Teacher Increases in Curriculum Understanding

As a result of participation in the NSF GK-12 program, how improved is your understanding of the entire science curriculum in your district (i.e., if you are a high school teacher, did your instruction benefit from interaction with elementary or middle school teachers in the program)?	**M/SD**
Elementary school	2.21*/.696
Middle school	1.93*/.616
High school	2.00/.655

*Significant at *p*<.05 (K-S); No significant between-group differences (Kruskal-Wallis); Scale: 1=Not at all improved; 2= Somewhat improved; 3= Significantly improved

In terms of teachers' instructional practices, the teachers reported significant increases in those practices that more closely resemble actual scientific investigations.

Table 25: Teacher Changes in Instructional Practices

How frequently do your instructional practices include the following?	M/SD: Prior to participation	M/SD: After participation
Hands-on work	2.76/.768	3.23*/.559
Use of computers or computer-based resources	2.11/.953	2.65*/.966
Experiments that include controls and replication	1.83/.760	2.68*/.661
Equipment intensive work	1.65/.688	2.12*/.821

*Significant pre-post at $p<.05$ (K-W); Scale: 1= Never; 2=Once in a while; 3=Regularly; 4=Frequently

Not only do teachers avail themselves of a more expanded palette of classroom activities, they explicitly attribute this change to participation in the project. This finding is most positive when considering elementary teachers (N=33) and least positive when looking at the high school teachers (N=15). There are many possible reasons for such a pattern, yet without further data speculations regarding this pattern are likely ill founded.

Table 26: Effects on Instruction Attributed to Participation

How differently do you design instruction in science due to your participation in the NSF GK-12 program?	M/SD
Elementary school	2.97*/.684
Middle school	2.67/.877
High school	2.27/.799

*Significant both within-group and between-groups at $p<.05$ (K-S, K-W); Scale: 1=No difference; 2=Minimal difference; 3=Some difference; 4=A great deal

The teachers were asked about five devices that were widely supported in the GK-12 project. Recalling that the biggest sub-group of teachers comprised elementary school teachers whose curriculum is probably less well-suited to these devices than high school teachers, the overall numbers here are rather low. Significant (Kruskal-Wallis) between-groups differences are noted below.

Table 27: Teacher Reports of Equipment Knowledge and Use

What equipment are you more proficient with due to participation in the program?	M/SD: Overall	M/SD: HS Only
Spectrometers - Knowledge	1.77*/.967	2.53/1.246
Spectrometers - Use	1.52*/.795	2.13/.990
Microscopes - Knowledge	3.57/.681	3.60/.910
Microscopes - Use	3.08/.955	3.13/1.125
pH meters - Knowledge	2.27*/.963	2.87/1.125
pH meters - Use	1.96*/979	2.40/1.056
Electrophoresis - Knowledge	1.49*/.860	2.67/1.113
Electrophoresis - Use	1.28*/.708	2.00/1.195
Thermal cyclers (PCR machines) - Knowledge	1.28*/.689	1.80/1.207
Thermal cyclers (PCR machines) - Use	1.16*/.436	1.53/.743

Significant between-group differences at p<.05 (K-W)
"Knowledge" scale: 1=No knowledge; 2=Minimal knowledge; 3=Some knowledge; 4=Considerable knowledge
"Use" scale: 1=No use; 2=Minimal use; 3=Some use; 4=Considerable use

The following table presents the findings from what teachers reported as student-level impacts. Note that for all variables the teachers reported statistically significant gains (4-point scale). This is a remarkably good finding, unusual for a project of this complexity, not to mention the limitations of the Fellows' presence in the classroom.

Table 28: Student Responses to Participation

Please indicate how the program affected your students both before and after your participation.	**M/SD: Prior to participation**	**M/SD: After participation**
Interest in science	2.35/.688	3.41*/.548
Interest in going to College	2.56/.663	3.17*/.685
Expressions of interest in science or engineering as a career	2.11/.689	2.99*/.647
Performance on science exams and/or exercises	2.37/.632	2.88*/.519

*Significant pre-post at $p<.05$ (K-W); Scale: 1=Poor; 2=Fair; 3=Good; 4=Excellent

In terms of their relations with other participants, teachers reported a significant widening of their professional network. The overall numbers show strong gains, and though much more could be done in this area, the project was highly successful in extending the teachers' professional social network.

Table 29: Teacher Changes in Professional Networks

How strong are your professional relationships due to the Program?	**M/SD: Prior to participation**	**M/SD: After participation**
Other Collaborating Teachers	1.67/.704	2.52*/.828
Former Fellows	1.28/.605	2.37*/.997
University faculty	1.44/.598	2.32*/.791

*Significant pre-post at $p<.05$ (K-W); Scale: 1=Very weak; 2= Just OK; 3=Fairly strong; 4=Very strong

Partner teachers reported with a strong consensus (the high school teachers varying somewhat more) that participation in the project helped them to be more effective in meeting the goals of Maine educational standards. Using a 3-point scale, teachers were nearly unanimous in saying that the project was helpful in this regard. This finding is important in that all-too-often science innovations are seen as falling somewhat outside educational policy goals. In this case, the introduction of new content appears to have helped to increase the participating teachers' sense of self-efficacy in meeting state goals.

Table 30: Benefits of Participation on Teacher Effectiveness

How did your participation in the program affect your ability to meet your obligations to the goals of the Maine Learning Results?	**M/SD**	**Value**
Elementary school	1.94*/.496	"The program contributed to my ability to teach material specified by the Maine Learning Results."
Middle school	1.85*/.534	"The program contributed to my ability to teach material specified by the Maine Learning Results."
High school	1.80/.775	"The program contributed to my ability to teach material specified by the Maine Learning Results."

*Significant at $p<.05$ (K-S); No significant between-group differences (K-W)
Scale: 1=The program did not contribute to my effectiveness in meeting my obligations; 2= The program contributed to my ability to teach material specified by the Maine Learning Results; 3= Without the program, I could not have met my responsibilities (i.e., strong enhancement of my abilities).

The teachers showed greater variability when asked about how many lessons they developed with the Fellow and that they continue to use. In this case, no values were significant and there were no significant between-group differences. This means that, most likely, some teachers are using more lessons and some are using fewer. The reasons for not using more lessons are explored in the following table, in which teachers, at a significant level, say that the lack of equipment is the most important factor inhibiting them from using more lessons. It is likely that the project's effects would enjoy a stronger level of sustainability if the teachers had adequate support for the ongoing implementation of the new content and methods.

Table 31: Number of Lessons Still Used by Level

How many lessons are you still using that you developed with a Fellow?	**M/SD**
Elementary school	3.00/1.225
Middle school	2.70/1.137
High school	2.20/1.014

Scale: 1=0; 2=1-3; 3=4-6; 4=7-10; 5=More than 10

Table 32: Factors Impeding Continued Use of Lessons

If you cannot continue using some lessons that you'd like to still incorporate into your teaching, how important are the following factors? Again, your answers need to add up to 100%.	**M/SD**
Lack of equipment	35.99*/24.923
Lack of supplies	27.04*/17.840
Too little preparation time	26.97*/25.549
Need for more than one person in the classroom during the activity	20.60*/15.919

*Significant at $p<.05$ (One-sample t-test); No significant between-group differences

When asked about the importance of the benefits of participation, the teachers were most likely to cite the collaboration with the Fellow and the new equipment. This finding is interesting in that it underscores the great potential and readiness for improvement among the teachers, when the agent of improvement can meet the teachers in a supportive, collaborative manner, as did the Fellows.

Table 33: Areas of Benefit for Teachers

Of these potential benefits of being a collaborating teacher, how important were these to you? Your answers need to add up to 100%.	**M**	**Std. Error Mean**
Collaboration with the Fellow	32.81*	1.843
Equipment provided by the program	27.01*	1.976
Lectures/activities during Science Camp	17.31*	1.242
Specific disciplinary knowledge	12.22*	1.118
Attending scientific meetings	9.74*	1.201
Making a presentation at a scientific meeting	4.57*	.645

*Significant at $p<.05$ (one-sample t-test)

Regarding the item on "specific disciplinary knowledge" in the preceding table, teachers cited the following as the subject matter areas in which they grew in knowledge. Note the extensive range of content, a recurring theme in the UMaine project.

Table 34: Subject Matter Areas of Teacher Growth

Subject Matter	N	Subject Matter (con't)	N
Biotechnology	1	Geology And Forestry	1
Biology	10	Geology, Biology	1
Burke Ecology	1	Geology, Marine	1
Chemistry	3	Life Science	1
Chemistry And B	1	Maine Geology	1
DNA Replication	1	Marine Biology	3
Earth Science	1	Marine Science	3
Ecology	2	Matter	1
Engineering	1	Microbiology	2
Environmental	1	Nutritional Science	1
Food Science	2	Ocean Sciences	1
Forestry	2	Ornithology	2
General Science	1	Physical Science	4
Genetics	2	Physics	1
Geology	12	Soils, Oceans	1

Table 35: Teacher Attendance at Scientific Meetings by Level

How many scientific meetings (i.e. annual meetings of a scientific society) did you attend as a Collaborating Teacher during the course of your participation in the NSF GK-12 program?	M/SD
Elementary school	3.21/2.058
Middle school	2.78/1.761
High school	3.07/2.086

No within-group items were significant (K-S), nor were there any significant between group differences (one-way ANOVA).

Teachers were asked a summative question on the overall impact of participation. The responses (based on a three-point scale) centered overwhelmingly around the central value ("Reinvigoration or enhancement").

Table 36: Teacher Reports of Overall Impact of Participation

What best describes the effect of the program on you?	**M/SD**
Elementary school (N=33)	2.21*/.600
Middle school (N=27)	2.11*/.577
High school (N=15)	2.20*/.775

*Significant at p<.05 (K-S); Scale: 1=No effect; 2=Reinvigoration or enhancement; 3=New direction

The question arises, however, whether the reported reinvigoration or enhancement received recognition from the broader school community. For this response, more than 2 out of 3 teachers said that it did not.

Table 37: Teacher Reports of Recognition

Did participation in the program contribute to your status or advancement in the teaching profession?	**N**	**Percent**
No	53	70.7
Yes	22	29.3

When asked to elaborate on their responses to the above question, about two-thirds of the teachers did not respond. Among those who did respond (N=23), the responses can be broken down roughly into two categories: those who received little or no recognition and those who said their GK-12 work had been recognized. The following table is a sampling of the responses.

Table 38: Sampling of Teacher Open-Ended Responses on Recognition

Little or No Recognition	Recognition
• Minimal recognition was made one of the six years I participated. • I didn't receive recognition, but that's the nature of the game, I guess. I talk to people about the NSF program and encourage folks to get into the science fields. • No, but as we talk about performance-based pay this type of program would enhance a teacher's salary if it contributed to their performance plan. • I feel that it essentially went unnoticed.	• I received recognition from my principal, superintendent, and my school board. As well as parents who were so interested in my experiences as well as their childrens' experiences with the fellows. • Colleagues recognized my abilities as a teacher of Science even more than I did! I found that the recognition gave me confidence and momentum to continue trying to teach better science, and to stay abreast of new knowledge in the scientific field. • All the teachers in the Orono School department were recognized in name. I don't believe it was noted on our personnel file, nor did it enhance our salary or upgrade professional ranking. It made the school look good and enhance our experience, giving us recertification credit. • Colleagues regard this experience highly and the Superintendent had articles in the local paper twice about this work.

Conclusions & Recommendations

The above data and analyses present a picture of a high-functioning and effective GK-12 project. Fellows from a complex array of backgrounds worked with an even greater collection of teachers at different levels and under different circumstances. It is clear from the data that the Fellows learned a great deal about teaching science in schools, and that the teachers learned a great deal about science and even the curriculum beyond their current assignments. The Fellows were adequately funded to continue in their university-based studies, and the Fellows experienced only minimal delays in completing their degrees. Finally, the Fellows emerge from the program with on going commitments to scientific outreach, a commitment they now see as a core value in their professional lives.

The foregoing data and findings present the broad patterns of participation effects among the Fellows and teachers. While the data do not permit a highly nuanced examination of the project details, DSRA finds that the UMaine project was distinctly and compellingly effective in the following areas:

- Fellows grew in their capacities to communicate innovative science content to naïve audiences, including partner teachers
- Fellows grew in their awareness of K-12 education
- Fellows appear strongly committed to the necessity and value of science outreach
- Fellows continued to pursue their university-based research and careers with success
- Partner teachers grew in science knowledge, as well as in their understanding of the overall science curriculum
- Partner teachers reported highly positive responses from students
- Partner teacher reported a commitment to using lessons developed in concert with the Fellows

As with any model of professional development, the UMaine model carries with it some limitations. For example, it is unclear how much dissemination the new materials and lessons will receive. The levels of administrative support are likewise uncertain, an essential element of a broader-based change in science teaching and learning. This sort of trade-off between the deeper and more individualized professional development (such as the UMaine model) and another broader and perhaps more superficial program may be inevitable. The former may exert a powerfully transformative force on a smaller group of participants, while the latter may work more effectively at bringing about far-flung, if incremental, changes.

With this last reflection in mind, DSRA recommends that future iterations consider

- Ways of building in dissemination with more active administrative support
- Ways of ensuring teachers have what they need in order to replicate new content
- Developing means for determining the effect of participation on student learning as measured by the state tests

Appendix 1: Fellow Publications and Awards

The following two lists are taken from what Fellows reported when asked about their publications and awards. These data are provided here as evidence of the high levels of activity and recognition among the Fellows. Of the 55 Fellows, only 12 (22%) did not provide any publications. Undergraduate Fellows were no less likely to publish or present than graduate Fellows.

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Awards

First name	Last name	Awards
Steven	Campbell	Howard L. Mendall Memorial Scholarship
Kristi Michele	Crowe	• Institute of Food Technologists Product Development Competition - University of Maine, 1st Place, Yo Bon Berry Bites, 2006 • Proctor & Gamble Co. Graduate Fellowship 2005-2006 • Fruit & Vegetable Products Division Graduate Poster Competition - 3rd Place, 2004 • Fruit & Vegetable Products Division Graduate Poster Competition - 1st Place, 2002 • UMaine Dow, Griffee, & Clements Agriculture & Forestry Outstanding Graduate Research Award, 2005
Christy	Finlayson	• 1st Place in Poster Contest: 4th European Conference on Invasive Species, Vienna, Austria Presentation Title: 'A Teaching Lesson about Biocontrol and Biological Invasions' • Honorable Mention in Poster Contest: Meeting of the Entomological Society of America, Fort Lauderdale, Florida. Presentation Title: 'Native and Non-Native Lady Beetles in Different Habitats: Testing the Habitat Compression Hypothesis'
Brent	Horton	AAAS Program for Excellence in Science, 2005 and 2007.
Caitlin	Howell	Ron Cockcroft Award.
Peter	Leach	• Best Student Oral Presentation, Developing International Geoarchaeology Conference, 2005, St. John, New Brunswick
John	Martel	• 2004 Recognition of Outstanding Scholarship and Service as a Citizen-Scientist, University of Maine Graduate College • 2003 President's Award, Acadian Entomological Society • 2003 Edith M. Patch-Frank H. Lathrop Prize in Entomology, University of Maine Department of Biological Sciences

First name	Last name	Awards (con't)
Jessica	Muhlin	American Society for Limnology and Oceanography 2007: Third prize in the Student poster competition.
Deborah	Perkins	• Frank M. Chapman Memorial Fund research grant, American Museum of Natural History • Kathleen S. Anderson Award, Manomet Center for Conservation Sciences • Percy A. Taverner Award, Society of Canadian Ornithologists • Exploration Fund research grant, Explorer's Club • New Jersey Division of Fish and Wildlife research grant Waterbird Society Meeting Best Student Poster Presentation Award • Marcia Brady Tucker Travel Award, American Ornithologists' Union
Heather	Short	The American Association of University Women American Fellowship for dissertation writing, 2005-2006.
Leigh	Stearns	• Outstanding Student Paper Award, Fall AGU Meeting (San Francisco, CA) Dec. 2005 • Best Student Presentation Award, CliC Meeting (Beijing, China), April 2005

Appendix 2: Survey Instruments (not attached to NSF report).

Addendum (June 20, 2007)

As stated in the evaluation report submitted June 6, 2007, two data points were deemed problematic and, as such, they were not reported at that time. In the period from May 31 to June 14, DSRA repeatedly emailed all participants, asking for responses to the questions on current employment and on the number of years required for graduation. Of the 55 Fellows, 44 responded, for a response rate of 80%.

On the first point, the data reveal that the number of years required for graduation was unlikely to be significantly greater than would have been needed without the Fellowship. Though there is no control group on this point, the following table presents a picture of students graduating at what can be reasonably considered to be within a normal period of time.

Table 39: Number Fellows by Degree and Years Needed for Graduation

	Reported Years Required for Graduation										
Degree	1	2	3	4	5	6	7	8	9	10	10+
BA			1	2							
BS	1	1	1	5							
MA		1									
MS	1	8	8	2	1						
PhD	1		1	3	7	4	1		1	1	

On the second problematic point in the June 6, 2007 report, namely that of the current employment status of the Fellows, the original data found that a full 42% were "looking for work." As this finding seemed highly unlikely, DSRA re-surveyed all Fellows. The following Table 2 below provides an updated, and in all likelihood, more accurate picture of the current patterns of employment among former Fellows. The revised data provide a far more reasonable figure of 8.6% as looking for work.

Table 2: *In what sector are you currently employed?*

Sector	Frequency	Percent
Industry (science)	6	10.3
Professor in a research university	3	5.2
College undergraduate professor	6	10.3
Homemaker	1	1.7
Medicine	3	5.2
Environmental (non-governmental)	2	3.4
K-12 teacher	3	5.2
Government scientist	2	3.4
Looking for work	5	8.6
Still a student	16	29.1
Other*	8	14.5
Total	55	100.0

*All in "Other" category are involved in science or science education, for example, working as researchers for an NGO, doing informal science education, etc.

Final Report (NSF 0231642)
Part I: Principal Investigator Report
A. Participants (6 pages, see attached pdf file of requested information for all participants during the project period for NSF 0231642).

B. Project Summary
1. Goals and Activities

The project had these major goals:
1) To provide stipend support for outstanding science, technology, and engineering students in support of their graduate studies while improving their communication and teaching skills through the outreach component of the NSF GK-12 Fellowship,

2) To provide role models of passionate (young) scientists and engineers to K-12 students to increase their interest in careers in STEM, while providing them with much greater opportunities for hands-on and creative, inquiry-based STEM,

3) To provide opportunities for K-12 teachers to improve their STEM backgrounds, particularly by placing them in a fully collaborative relationship to the NSF GK-12 Fellow; to make it possible for K-12 teachers to meet their responsibilities under the *Maine Learning Results* (1997) in Science & Technology (N.B., These legislatively passed goals are very specific, grade-band groupings of required knowledge for Maine K-12 students in a variety of fields from evolution to physics), and

4) To build relationships between the University of Maine and K-12 districts.

It is most helpful to discuss the project's accomplishments with respect to these goals in the context of the 6 years of its duration (0231642 was a renewal of the original 3 year grant [9979581]), and we commissioned a summative external review of the project by Dr. Russell Faux of Davis Square Research Associates (Somerville, MA) during the spring of 2007 that covers both grant periods (see attached). The importance of this is that many of the NSF GK-12 Fellows appointed during 0231642 are still graduate students at the University of Maine, whereas nearly all of the students appointed under the previous grant are established in academic, industrial, governmental, and non-profit jobs or postdoctoral study. Further, of the 94 living teachers who participated in the project, about half were participants only through year 4 of the 6 year project; thus, here, too, the lens of time for observing effects of the program is benefited by a full summative view of our NSF GK-12 project.

2. Activities associated with project.
a. Selection of Fellows. In each year, Fellows were selected by an application process that was run through the Graduate School to ensure fairness, rigor, and institutionalization of the awards. The PI/Co-PIs modeled the written application after the NSF GRF application, with added essays to reflect aspects that were pertinent to the NSF GK-12 goals. Applications were made available by the Graduate School and received by them. Applicants were then sorted into a top group of students, with that

group numbering 2-3 times as large as the final number of awards to be made; this "cut" was made by the PI/Co-PIs on the basis of grades, letters of recommendation, and the quality of the written application (e.g., essays). Students in the top group were invited to sit for an interview (30 minutes) with one of three concurrent panels; each panel was composed of 3 Collaborating Teachers in the GK-12 program and 3 University of Maine STEM faculty, including the PI and Co-PIs, who were distributed as Chairs/Co-chairs of panels. The panelists, who had the full application of each candidate prior to the interview, then ranked all interviewed applicants at the end of the day, and the panels convened together to select the students to be offered fellowships and those to be put on a waiting list.

This procedure for selection of NSF GK-12 Fellows was one of the most important components of the success of the program. It achieved wide publicity for the program, and it gave all parties (faculty and collaborating teachers) a sense of full ownership of the program. This was an expression of trust from the University to the K-12 teachers that they told us was refreshing. Most importantly, it selected our very best STEM graduate students (9/year) and rising seniors (3/year) as NSF GK-12 Fellows.

b. Training sessions, workshops, seminars, and other professional development. We held a one-week Science Camp during the first week of August for appointed NSF GK-12 Fellows and Collaborating Teachers. This period seemed to be of just the right duration to accomplish all of our goals: a) cutting-edge science activities for teachers and b) bonding/initial curriculum planning between each team of teachers and fellow. During NSF 0231642, a Fellow was typically paired with 2-3 teachers from districts within the Penobscot River Educational Partnership (PREP) and with one teacher from a distant district in Maine ("PROP" for Penobscot River Outside Partnership). PREP teachers' classrooms were located from 5 minutes to 1 hour of driving time from the University; PROP schools were typically 2 hours from the University. Fellows worked weekly with the PREP teachers and a few times during the year with the PROP teachers. However, the PROP work was done intensively; the Fellow and Teacher made arrangements with other teachers for students to spend all day in activities with the Fellow on those occasional visits, and PROP students also came to the University at least once during the year for lab work and demonstrations [e.g., of the Ice Core Lab] here. Over 40 STEM faculty participated in our Science Camps over the 6 years of the project, and teachers remarked constantly about the quality and breadth of opportunities at the University of Maine, which had been unknown to them before. This was true even of teachers who taught at the neighboring schools to the University (e.g., in Orono and Old Town). At Science Camp, we invited some of the collaborating teachers to do special, additional sessions just for Fellows on issues including student behavior, learning styles, and curriculum planning. We also invited colleagues in the College of Education to run discussions on the *Maine Learning Results* and Rubric teaching. An important part of the success of all Science Camps was an overnight trip to do a series of activities together (e.g., to the University's Darling Marine Center). This promoted bonding. In short, we tried to model in Science Camp what we wanted to achieve during the year.

During the school year, we held quarterly meetings for all participants and weekly seminars for Fellows. Each quarterly meeting was hosted by a different group of Collaborating Teachers in one of the participating K-12 schools, and at least 3 Fellow/Teacher teams presented information on activities they'd done in the classroom. Of course, these regular meetings maintained project cohesion, and allowed us to make various announcements or policy decisions as a group. The weekly seminars for Fellows included professional information (e.g., how to find a good postdoc; how to write a successful research grant) and presentations of original lesson plans by Fellows. Each Fellow was a presenter each semester. These weekly sessions also kept everyone working together toward the project's goals. One of the most important things achieved by these meetings was that our best graduate students found themselves in a cross-disciplinary group whose members became quite close to each other in most years. This is the only venue for this sort of interdisciplinary science at the University of Maine, and would not have been achieved if our program had been limited to Ecology or Geology or whatever.

One of the most important opportunities offered to teachers through the program was to attend and present papers at annual meetings of professional societies. Some teachers were funded to attend conferences during the first 3 years of our 6 year project. During the last 3 years of the project, most teachers were able to attend a conference/year (e.g., American Chemical Society, Society for Conservation Biology, Ecological Society of America, Geological Society of America, etc.). We have been surprised by how few NSF GK-12 projects have offered these opportunities to Collaborating Teachers (see Recommendations in Part III, below). These opportunities were offered to teachers to attend a professional meeting that their Fellow would be attending, and so they were able to be guided to good paper sessions, meet many other professionals, etc. They were initially amazed by the respect that scientists at these meetings accorded them (this is a sad reflection of the lack of connection of K-12 and university science in the US).

c. Curriculum materials developed. Each Fellow developed his/her own curriculum in collaboration with the Collaborating Teachers. Some of the best of the original lessons from the project are currently on the Project website (16 lessons). These were put up 3 years ago, and as of 8/1/07, 28,417 visitors have used the site. We have prepared a few additional lessons during 2006-07, and a CD with these lessons will be distributed later this year to all teachers who participated in the project. Some lessons have been published or used elsewhere. For example, the American Museum of Natural History in New York included one of Fellow Jonathan Schilling's lessons in a book (see publications). The Institute of Food Technologists has placed several of our lessons on one of their sites with our permission. We tried to have the collection of culled lessons published by the University of Maine Press this year, but the Editor did not think K-12 material was suitable. As the external evaluators' report attests, teachers are continuing to use many of the Fellows' lessons (including a great number that were not in our "primo" collection).

Our activities spanned the full range of STEM fields because of the interest/desires of the participating K-12 districts. We accepted the role of doing what they told us they needed---not imposing a particular program on them; this made a big difference to the effective beginning of our K-12/University relationships. We also had outreach beyond the outreach, when some Fellows and their Collaborating Teachers did longterm projects in Sunkhaze Meadows National Wildlife Refuge (engineering/physics projects designing and building boardwalks, biodiversity studies of small mammals, etc.). Carrying forward our interest in fostering real science in K-12, several Fellows did major projects throughout the year with multiple classes of elementary and middle school students:

1. A study of dispersal stages in fucoid seaweeds done with orange fruit release and recapture studies on the Maine Coast (elementary students, Fellow J. Muhlin),
2. Pre-dam removal biodiversity study of shoreline (middle school students, Fellow K. Miller), and
3. Effect of different foods on bird foraging (middle school students, Fellow Horton).

2. Communication A complete list of publications is attached to the end of the External Examiners' report. These include publications related directly to the outreach component of the award and research publications from Fellows' thesis work. Obviously, the number of Fellows' research (thesis) publications will increase in the next few years. The following are notable for the outreach component:

Calder et al. 2003. *J. Food Sci. Education* 2:58-60.

Campbell et al. 2005. *Frontiers Ecol. Environ*. 3: 153-160.

Horton, B.M. 2005. Bird Study in the Classroom and Out: Maine students get involved in science through Project FeederWatch. *Birdscope,* Spring Issue. Cornell Laboratory of Ornithology. (this reference and a research publication by Horton were omitted from the External report, by accident apparently).

Schilling, J. S. 2005. In: *Invertebrates: Ecological and conservation importance*. How can habitat affect biodiversity? A field experiment with aquatic communities. Center for Biodiversity and Conservation of the American Museum of Natural History. New York, N.Y. (this reference and several of Schilling's research publications were omitted from the External report, by accident apparently).

Please note that the PI/Co-PIs are currently preparing several manuscripts on the project based upon the External Examiner's report. Therefore, we request that NSF not make this report (appended in full) available to other investigators, who might use this for educational policy research, for one year from August 1, 2007.

2. No books were published.

3. Our website (www.umaine.edu/NSFGK-12/) will not be left up after summer 2007, but was very valuable during the project to many parties. It has been widely used; as noted above, the Lesson Plans page alone has received 28,417 visitors.

Part II. External Examiners' Report (Dr. Russell Faux, DSRA)

This is appended, in full, but the summary and conclusions/recommendations are copied below.

"**Executive Summary** (p. 1 of Summative Report, June 6, 2007, Davis Square Research Assoc.)

The following report presents the methods and findings of summative evaluation research activities conducted by Davis Square Research Associates (DSRA) in the spring of 2007 on the effectiveness of the University of Maine GK-12 project. This project supported University of Maine graduate (largely) students in science and engineering as they worked with local K-12 teachers. The project being evaluated in this report ran from 2000 to 2006, with 55 Fellows working with 96 different teachers. The goals of the project included helping teachers meet their responsibilities in Science and Technology within the *Maine Learning Results*, supporting science and engineering Fellows' chosen studies, improving the Fellows' skills at communicating science content, and strengthening the school-university connection. The current evaluation is based upon data gathered through three separate online surveys of the Fellows, partner teachers, and University of Maine professors who were either the major professors of the Fellows or the advisors of the undergraduate Fellows.

The key findings of the study include:

- Fellows reported, and exhibited to partner teachers and advisors, growth in their skills in teaching and communicating science content
- Fellows reported a heightened awareness of, and commitment to, K-12 science education and science outreach.
- Partner teachers, especially at the elementary level, reported gains in science knowledge and science teaching skills.
- Partner teachers reported that many of the lessons developed in collaboration with Fellows would continue to be implemented.
- Fellows reported that their progress toward degree completion was slowed slightly, but that the benefits of the GK-12 Fellowship for their careers were evident.
- The quality of the university-based research was reported to be unaffected by the GK-12 commitments
- There is ample evidence of the Fellows having made considerable progress in their careers in science and engineering.

Conclusions and Recommendations (p. 35-36 of Summative Report, June 6, 2007 Davis Square Research Assoc.)

The above data and analyses present a picture of a high-functioning and effective GK-12 project. Fellows from a complex array of backgrounds worked with an even greater collection of teachers at different levels and under different circumstances. It is clear from the data that the Fellows learned a great deal about teaching science in schools, and that the teachers learned a great deal about science and even the curriculum beyond their current assignments. The Fellows were adequately funded to continue in their university-based studies, and the Fellows experienced only minimal delays in completing their degrees. Finally, the Fellows emerge from the program with on going commitments to scientific outreach, a commitment they now see as a core value in their professional lives.

The foregoing data and findings present the broad patterns of participation effects among the Fellows and teachers. While the data do not permit a highly nuanced examination of the project details, DSRA finds that the UMaine project was distinctly and compellingly effective in the following areas:

- Fellows grew in their capacities to communicate innovative science content to naïve audiences, including partner teachers
- Fellows grew in their awareness of K-12 education
- Fellows appear strongly committed to the necessity and value of science outreach
- Fellows continued to pursue their university-based research and careers with success
- Partner teachers grew in science knowledge, as well as in their understanding of the overall science curriculum
- Partner teachers reported highly positive responses from students
- Partner teacher reported a commitment to using lessons developed in concert with the Fellows

As with any model of professional development, the UMaine model carries with it some limitations. For example, it is unclear how much dissemination the new materials and lessons will receive. The levels of administrative support are likewise uncertain, an essential element of a broader-based change in science teaching and learning. This sort of trade-off between the deeper and more individualized professional development (such as the UMaine model) and another broader and perhaps more superficial program may be inevitable. The former may exert a powerfully transformative force on a smaller group of participants, while the latter may work more effectively at bringing about far-flung, if incremental, changes.

With this last reflection in mind, DSRA recommends that future iterations consider:

- Ways of building in dissemination with more active administrative support
- Ways of ensuring teachers have what they need in order to replicate new content
- Developing means for determining the effect of participation on student learning as measured by the state tests"

III. Collaborative Response Report

1. Response to DSRA report. The Summative Evaluation by Davis Square Research Associates confirms that our project met the goals established for the project (see I. above). Additionally, the project was nominated by the University of Maine for the New England Board of Higher Education's Regional Project Excellence Award in 2005, and with strong competition from other successful projects of many types in New England, won this prize. The award was presented to the PI/Co-PIs at a banquet in Boston, and it is displayed prominently in the Graduate School at the University of Maine. There was also a Legislative Sentiment passed by the Legislature of the State of Maine in 2005 to recognize the achievements of our project.

Individual Fellows and Collaborating Teachers won several prizes directly related to the outreach component of the GK-12 program (see Table in External Report, p. 48-49: Christy Finlayson, 4th European Conference on Invasive Species, Vienna, First Place in Poster Contest; Leigh Stearns, Climate Change Meeting [Beijing], Best Student Presentation Award), as well as responding to invitations to present work on the project at major symposia of Scientific Meetings (e.g., 2004 International Waterbird Congress; 2005 American Society of Limnology & Oceanography meeting). Fellows won other prizes connected to their supported thesis work (see Table in External Report, p. 48-49).

DSRA recommended that any future continuation of this project should develop means to determine whether the project had an effect on K-12 students' scores on the State tests that track achievement related to the Maine Learning Results (i.e., the Maine Educational Assessment tests or MEAs). We agree strongly with the importance of this determination but, in practice, it is very difficult. First, it would require a budget for evaluation that is not provided by the NSF GK-12 project, or which would have strongly jeopardized our success by drawing funds away from the Fellows' and Teachers' activities. There are also well recognized problems of adequate controls and difficulty in screening multiple effects on students' performance in educational research that affect rigorous determination of effects of this project on student scores. Perhaps most important, however, is that we found the test is flawed as a tool to chart students' year-by-year improvement in different areas of STEM that we were affecting. This is because the number of questions and the difficulty of the questions is not kept constant in subareas of the MEA (e.g., in Science & Technology) from year-to-year. Without a constant level of difficulty, scores that rise and fall from year to year are meaningless in a factorial analysis of the effect of the NSF GK-12 program. However, Collaborating Teachers indicated that the program was important to meeting their responsibilities under the *Maine Learning Results* (see External Report, p. 28), and they attributed better K-12 student performance on science exams and exercises to the NSF GK-12 program (p. 28, External Report).

DSRA also recommended building in more administrative support for teachers and making sure they have what they need to sustain the Fellows' lessons when the project ends. DSRA was not aware of the scope of equipment transfers by our project and administrative changes in Maine K-12. We transferred all of the project's equipment (i.e., microscopes, thermal cyclers, etc.) to the schools (PREP and PROP) during 2006-07, and the transfer carried with it each Superintendent's signed commitment to maintain the equipment and to make it available for sharing across districts in response to reasonable requests. All equipment was dispersed under the care of a GK-12 teacher at each school, and a full list of those contacts was circulated to all Collaborating Teachers. We know that much of the equipment is being shared. Especially in the case of the microscopes, the teachers are so much better trained because of the NSF GK-12 project that a great deal of hands-on work is occurring in the absence of the Fellows because of the equipment availability. The administrative support that teachers need includes a resources' person to prepare reagents, restock kits, etc. In short, teachers are so busy in a succession of classes during the day, that many skilled teachers would do more hands-on work if they had a small amount of assistance to prepare labs (i.e., a teaching assistant/school).

Maine is currently in the midst of an ambitious district consolidation plan (nearly 200 districts will collapse to 80). We anticipate that while there may be disadvantages of this, one of the strong benefits will be more shared curriculum (less reinventing the wheel) across schools for teachers and the potential to move administrative salary funds into support positions and higher teacher salaries. On the local scale of Maine, the consolidation holds promise for broader implementation of some of the achievements of our NSF GK-12 project.

2. Sustainability. The PI/Co-PIs of our project made vigorous attempts to sustain the GK-12 project:

1) We obtained a written promise from Provost Robert Kennedy, who became President during our project, to sustain the program by building the Provost Fellowships to appropriate numbers and funding levels to continue the program after NSF funding ceased. This promise was not kept, but during the project about 3 Provost Fellows/year worked in the project as if they were GK-12 Fellows and this extended the numbers of teachers and students we were able to reach.

2) The PI met twice with the Vice President for Development in 2003-04 to urge solicitation of funds for endowment of GK-12 fellowships. The response was favorable, but did not result in solicitation of fellowship monies by the University.

3) Our project invited the other two GK-12 projects in Maine (one at the University of Maine and one at the University of Southern Maine) to join us in proposing a Bill to the Chancellor of the University of Maine System. The Chancellor responded favorably; we wrote a bill; it was introduced by several legislators and heard by the Joint Committee on Appropriations as LD 113. It passed the Legislature in spring 2005 but was not funded, due in part to concern about the State economy as military bases in Maine were closed.

Although we failed to sustain the project, a number of "pieces" are being sustained. One of our pedagogical goals was to introduce "real science" with controls and replication into work in K-12. As the External Report found, this was done with great success and will continue (see p. 26 of appended report). While not all of the lessons can be continued by Teachers, many can be and are (see p. 29-30 of external report). Fellows continue to do outreach post-fellowship (p. 21 of external report). Students are more interested in science and going to college, and the role model of the Fellow continues to resonate with K-12 students (p. 28). We believe that the Fellows' sense of improved self confidence, teaching and communication skills will have important career outcomes (see p. 12 and also p. 13, 15, 18, 19 of external report). And the career outcomes for the Fellows are excellent (see Part I and Addendum to External Report). To date, of the 55 living Fellows (David Veverka was killed in Iraq with his Guard Unit in 2006), 4 are already professors in research universities and 7 are professors at undergraduate colleges (see External Report Addendum; one additional Fellow is added to each category in the Addendum, because of hires made post-evaluation of Dr. Thomas and Dr. Campbell, known to the PI, with proportionate reduction in "Looking for work" in p. 2, Addendum). Other Fellows have prestigious postdoctoral appointments (e.g., Smithsonian Postdoctoral Fellow Horton, Fulbright Scholar Perry) or are working in industrial research/education (e.g., *Southern Living* Food Scientist Crowe, Research Scientist Gilman at Horton Seafoods) or serving as medical doctors (e.g., Dr. Morse, now in a residency) or working for non-governmental organizations (Wilderness Society Program Manager Perkins). Fellows recognize the key advantages that having been a NSF GK-12 Fellow provide in the STEM job market, including academia (see comments from Fellows on p. 22 of the External Evaluation).

We close our final report to NSF by quoting several of the (anonymous) comments from Fellows in the External Examiner's Report (p. 15), and with a list of Recommendations (Project Best Practices).

Fellow 1: I had worked for several years as a T.A. before getting the NSF fellowship. The fellowship was a much better teaching experience than being a T.A. because I could design my own lectures and laboratory activities.

Fellow 2: As a senior medical student, I am now responsible for teaching the first years as well as my patients. The ability to verbalize concepts to a varied population (i.e., a scientist, children, parents, care-takers) was a skill I developed through my experiences in the NSF program. Invaluable.

Fellow 3: I learned to tailor the information to the target audience. Learned how to explain concepts in many different ways. The NSF program also made me a much more effective TA through planning lessons and communication skills.

Fellow 4: This fellowship greatly increased my ability to speak clearly and concisely in front of a group…It also taught me how to teach concepts from different angles in order to reach students at all learning levels, and how to present things so that the students are encouraged to think and discover for themselves.

Recommendations (Project Best Practices)

1. Fellows should be selected (jointly) by University STEM faculty and Collaborating Teachers/Administrators from K-12 in a rigorous process based in the University's Graduate School (see above).
2. K-12 Teachers (and administrators) should be involved in writing/planning of the grant: Our project was a partnership from the beginning.
3. GK-12 programs that work will have "feet on the street" (STEM PI/Co-PIs who are keenly invested in the project).
4. Fellows' individual passions must have a key place (flexibility in curriculum to meet project goals while maximizing individual strengths).
5. Fellows and Teachers must exhibit partnership in the classroom; they need to meet regularly to plan/bond.
6. Distribute a clear and detailed statement of benefits and responsibilities of participation in the GK-12 project to all parties (e.g., Fellows, Teachers, CurriculumCoordinators/Superintendents, Major Professors); require return of a signed end sheet that acknowledges acceptance of these by each party.
7. A Coordinator is needed to assist the PI/Co-PIs with routine administration, etc., and a former GK-12 Fellow who is still a graduate student is ideal.

8. Fellows must spend enough time with their classes to get to know the students well and be real role models (i.e., we do not favor a model that results in great dispersion of Fellows' efforts).
9. Provide opportunities for teachers to expand their STEM backgrounds and self-confidence (and fun!) through attendance and co-authorship with their Fellow of papers at annual meetings of professional science societies.
10. Keep it professional; Science Camp needs cutting edge science activities as well as planning time and bonding experiences.
11. Strong bonding of Fellows made everything easier and was achieved by assembling an interdisciplinary group of excellent students, and recruiting them to a "bearer of the torch" view of the important goals of the program through Science Camp, weekly seminars, and parties. Don't forget the parties.