Program Evaluation Report for Year 2
Of the **BioTeach Program of the MassBioEd Foundation**

Polly Hubbard
Jim Hammerman
Karen Mutch-Jones

With work from additional team members
Jana Marcotte
Deborah Munson

TERC
Cambridge, Massachusetts

June 2007

Table of Contents

Executive Summary

Evaluation Overview

This report summarizes outcome data associated with the BioTeach program from July 2006-June 2007. Evaluators collected data to answer the following questions.

I. To what extent do various constituencies participate in BioTeach?
II. What do teacher and guidance counselor participants learn about biotechnology from their BioTeach professional development?
III. To what extent and how do various constituencies implement new learning and change their behaviors as hoped for by the BioTeach program?
IV. How do students' experiences in class change as a result of their teachers' and schools' participation in BioTeach?
V. To what extent do these changes result in long-term changes in attitudes and knowledge in biotechnology for students?
VI. To what extent do schools that participated in BioTeach sustain biotechnology classroom and school efforts over time?

Readers may refer to the Year One Report for more detailed descriptions of the evaluation and the program. Tools used to gather data for this report are in Appendix A. Formative feedback has been regularly provided to program staff since September 2006, and, where relevant, has been incorporated into this document.

A note about percents and means: The number of people reporting on different questions varies as all items did not apply to all people and people sometimes skipped individual items. To avoid confusion the report does not identify the exact number of respondents for every question but only reports summary results, such as means and percent of respondents in different categories, when numbers are large enough to permit reasonably stable estimates of these values.

Recruitment and Characteristics of Cohort Two

The BioTeach program is designed to educate high school biology teachers because among the Massachusetts science standards, the topic of Biotechnology is most clearly articulated in the Biology Content Standards that guide instruction. In prior years, the program has been open to science teachers in any domain as well as administrators and guidance counselors because it was assumed that people in these roles could help further the goals of the program. This year, program staff acknowledged that the program was focused on augmenting teachers' content and technical knowledge and that guidance counselors and non-teaching department chairs had no opportunity to apply what they might learn from the summer institute to students so they were not recruited. This year the 105 Cohort Two participants were largely biology teachers with only six teaching some other science altogether. 34% have had some prior biotechnology training. **These findings indicate an opportunity to devise professional development curricula for those starting at the intermediate level that builds off teachers' prior knowledge**. Refer to Table 1 for key characteristics of Cohort Two.

Table 1: Cohort Two participant characteristics

Role	Number	Percent
Teachers	75	71%
Department Chairs, teaching	15	14%
Administrators, non-teaching	1	1%
Other	2	2%
Missing data	12	11
Courses Taught Prior to Training	**Number**	**Percent**
General Biology	57	70%
Honors Biology	23	34%
Other Biology Related	22	51%
AP/Second Year Biology	20	32%
Only Non Biology	6	6%
Biotechnology	5	9%
Biotechnology Training During Previous 5 Years	**Number**	**Percent**
No other biotechnology workshops	55	52%
Some biotechnology workshops	36	34%
Missing data	14	13%

Note: Teachers may teach more than one course so prior teaching experience will not sum to 100%. The N for Role and Training questions is 105.

Changes To Training

The BioTeach program consists of initial three-day summer training in how to use equipment, understand the science content, and deliver instruction for three wet labs for high school classes, followed by six annual one-day trainings for teachers who received the initial training. During Year Two, BioTeach maintained the same basic structure for initial training for small groups of 20 participants. Training expanded from two to four locations: Boston University CityLab, Framingham State College, Springfield Technical College, and the Boston Museum of Science. The expansion was designed to increase access to schools outside of the Boston area and decrease travel time for teachers particularly from the Greater Boston and western parts of the state.

This years' trainings were modified to address concerns that teachers were not integrating the labs of the summer training into their classroom teaching, or using the equipment to teach other biotechnology labs from other sources. Curriculum developers were observed to have:

- Added a Pre-lab activity to each wet lab. Pre-labs introduced concepts, outlined the relevance of the lab to daily life, and/or provided mini-lessons on key skills
- Reduced the number of labs taught from four to three to allow more time for learning
- Scheduled Collegial Exchange time for teachers to discuss teaching biotechnology in their schools and share resources
- Provided additional free time for supervised Lab Practice
- Provided a Question and Answer session termed Science Content Check

- Provided integration activities to connect topics more closely to the school curriculum
- Emphasized the expectation that at least one of the labs presented during training would be taught to students during the current academic year
- Included a college-level training provider (Framingham State) to increase the quality of the Follow-up day instruction and provide access to appropriate lab facilities
- Differentiated follow-up day training to present an option for a lab that was new and/or more technically advanced
- Reduced the career awareness information to the cohort by using other sites instead of biotechnology companies for follow-up training

Refer to the Year One report for details of unchanged training goals and training design.

Impact of Training

Impact of training was determined by comparing pre- and post-workshop surveys about the summer workshop, observing the winter workshop and informally interviewing participants, visiting fourteen schools for on-site group interviews, and analyzing a late spring survey from teachers and department chairs about the extent of implementation.

Summer Workshops

Teachers attending the summer institutes completed surveys prior to and immediately following their initial training to identify what they felt they had learned and how prepared or confident they were to integrate the labs into their classrooms.

Participants report clear evidence of learning during the summer workshops. The most notable increase shown in Table 2 was in knowledge about "How to incorporate biotech curriculum into the science courses you teach", and the smallest average increase was in knowledge about "Careers in biotechnology", although all items showed statistically significant gains. **Connection between careers in the life sciences and the summer training is not strong and, given its stated goals, the program should reinvest itself in developing summer training activities that more directly instruct teachers about this topic.** Changes in knowledge about how to *teach* topics were greater than changes in general knowledge *about* those topics and statistically significant[1]. Similarly change in knowledge about "How to teach about *procedures and techniques* in biotechnology" was greater than change in knowledge about "How to teach about *concepts* underlying biotechnology". The training seems to be effective both in teaching lab techniques and in teaching about biotechnology concepts, though it is somewhat less effective in teaching concepts than techniques.

[1] Change in overall average of teaching topics = .93, $t=13.3$ ($df=83$), $p<.001$; change in overall average of content knowledge topics = .54, $t=9.0$ ($df=84$), $p<.001$.

Table 2: Summary of self-rated change in participant knowledge after the summer training based on a scale from 1 (none or very little) to 4 (extensive)

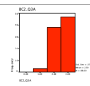
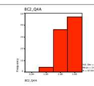
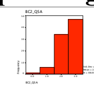
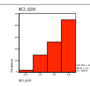
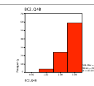
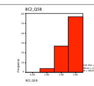
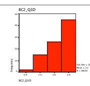
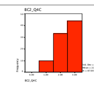
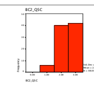
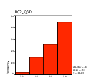
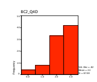
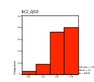
Topics	Pre-Survey Mean	Post-Survey Mean	Mean Pre-/ Post-survey Difference	Std Error of the Difference
How to incorporate biotech curriculum into the science courses you teach	2.01	3.22	1.21**	0.087
How to *teach about* procedures and techniques used in biotech	1.95	3.00	1.05**	0.079
How to *teach about* concepts underlying biotechnology	2.22	3.05	0.83**	0.092
Procedures and techniques used in biotechnology	2.37	3.05	0.67**	0.077
How to *teach about* careers in biotechnology	1.99	2.63	0.64**	0.087
The role of biotechnology in modern life	2.88	3.47	0.58**	0.077
The definition of biotechnology	2.81	3.37	0.56**	0.084
Biology concepts underlying biotechnology	2.86	3.33	0.47**	0.085
Careers in biotechnology	2.49	2.86	0.36**	0.080
Average	**2.40**	**3.11**	**0.71****	**0.083**

Note: All differences are statistically significant using a paired samples t-test at the ** $p < .001$ level. N=84 or 85 for all comparisons.

Participants reported relatively high ratings for learning key activities necessary for successfully teaching the three labs to students. Average responses for all activities and labs were high, in the “Moderately” to “Extensively” range. The item, “Integrate the lab with your curriculum” had the most “Not at all” responses, indicating the training was less successful at this aspect. Note, too, that different sites were not able to offer all the integration activities as planned. See Table 3 for average rating for each activity on a four-point scale where 1 means Not at all, 2-Somewhat, 3-Moderately, 4-Extensively and thumbnail graphs of the distribution of responses. The right most bars in the graphs reflect the highest possible rating of 4-Extensively.[2]

[2] In the original Summer Workshop report, these scales went from 0 to 3. They have been rescaled to allow comparison with scales from the spring Survey.

Table 3: Self report ratings of teacher ability just after summer training

Lab-Related Activities	Bacterial Transformation		Gel Electrophoresis		DNA Fingerprinting	
…Learn more about the laboratory equipment	3.50		3.49		3.44	
…Understand and complete the lab techniques	3.58		3.63		3.60	
…Discuss and interpret the results	3.48		3.39		3.41	
…Integrate the lab with your curriculum for at least one class	3.30		3.30		3.28	

Participants left the summer workshops feeling much more prepared than they entered. Table 4 shows clear evidence of increased preparedness to teach lab techniques to students after the summer workshops—an average of 1.5 points from "Somewhat" prepared to between "Moderately" and "Extensively" using a 4 point scale where 1-Not at all, 2-Somewhat, 3-Moderately, 4-Extensively prepared.

Table 4: Summary of teacher change in preparedness to teach labs

Labs in Training	Pre Survey Mean	Post Survey Mean	Mean Pre-/ Post-survey Difference	Std Error of the Difference
Bacterial transformation	1.90	3.45	1.55**	.100
Agarose gel protein electrophoresis	2.10	3.56	1.46**	.104
DNA fingerprinting through restriction analysis	2.05	3.54	1.49**	.095
Average	**2.02**	**3.52**	**1.50****	**.100**

Note: All differences are statistically significant at the ** $p<.001$ level. N=81 or 82 for all comparisons. There is no statistically significant difference in the amount of increased preparedness across these labs.

Winter Workshop

Program staff and evaluators expect and observe a drop off from the motivated, confident teachers of summer to the more challenging contexts of actual schools. To help teachers remain prepared, the program offers a one-day intensive training at mid-year.

This winter workshop training or follow-up day for 123 (of a possible 225) participants was refocused from the previous year to allow more time for practicing the labs. Five different lab sessions were presented with teachers choosing one from: a) Bacterial transformation, b) agarose gel protein electrophoresis or c) DNA fingerprinting through restriction analysis (the 2006 summer training menu) or d) Polymerase Chain Reaction (PCR) or e) Miniprep (originally offered only to Cohort One in 2005 training). Two speakers mid-day discussed state science standards and strategies used in successful science instruction and teachers shared plans for integrating labs into curricula during concurrent "Jigsaw" sessions in the afternoon.

Overall, the workshop was rated "Good" to "Excellent" (3.26 average (SD=.78) on a four point scale where one was poor and four was excellent[3]. Teachers rated the "usefulness" of sessions, rather than the extent to which they learned as in the summer. The morning lab sessions received higher ratings on "usefulness" to teachers' teaching than did the mid-day lectures and afternoon jigsaw integration sessions. Refer to Quarterly Report Seven for more details and instruments.

Observers noted that teachers attending the winter workshop had a wide range of knowledge and experience. While the program as implemented was useful to most teachers attending, a sizeable fraction (perhaps 25%) were prepared for a more sophisticated program, such as one focusing on careers or cutting edge applications. The percentage of prepared teachers will surely increase as the program is designed to last six years and those at the mid- to end-point of a six-year training can logically (and empirically) be expected to know more than those at the beginning.

In addition, of the 225 possible attendees (those that received training years one and two), only 120 people attended or 53% of those who were required to attend and of those attending, observers and the program manager noted several schools sent new teachers to the follow-up days who had not been trained at all. This number could not be confirmed because attendance records did not denote the cohort for each attendee. There is a tension between the requirement that all previously trained teachers attend regardless of ability level, and the fact that some teachers are well prepared and may not feel they need a refresher course. Departments may undermine the requirement that previously trained teachers receive more training as well, as they might desire some training for every teacher in the department rather than a lot of training for one. **The program should make a choice about whether it will provide more advanced or different kinds of training for those involved for 4-6 years, or whether it will remain an introduction to the field for the less experienced teacher. Once that decision is made the requirement to attend a follow-up day can be re-examined and initial recruitment and ongoing training can target appropriate teachers.**

Implementation

The remainder of the report is based upon 113 on-line survey responses submitted in May, 2007, by 39 (34% of responses) Cohort One teachers and 75 (66% of responses) Cohort Two teachers and augmented by interviews during the winter and spring, 2007, with 46 educators from 14 schools representing both cohorts.

Labs

---

[3] Data collected by Framingham State Program Coordinator on surveys of their own development.

113 Teachers reported they presented biotechnology skills or concepts to 6,964 students first semester and 7,073 the second semester in a total of 802 sections or classes. It is impossible to tell whether or not these were unique individuals—some students could have taken a two-semester course and if we add the first and second semester we obtain a misleading figure of total students taught. However at least 7,073 were instructed.

These skills could have come from the BioTeach labs or other labs the teachers used. This is a substantial increase from the 4,200 students estimated for Year One. Teachers taught the lessons during the courses listed in Table 5.

Table 5: Courses in which biotechnology was taught post summer training

	Number of Teachers and Students Reached by BioTeach							
	First Semester				**Second Semester**			
Course	**Teachers**	**Total Students**	**Total Sections**	**Avg Class Size**	**Teachers**	**Total Students**	**Total Sections**	**Avg Class Size**
Intro/ General Bio	63	3974	213	18.7	71	4306	229	18.8
AP Bio	17	254	20	12.7	14	203	15	13.5
Biotech	6	144	21	6.9	6	144	18	8
Anatomy/ Physiology	12	441	26	17	11	400	20	20
Forensics	7	324	18	18	10	386	19	20.3
Marine Science	4	199	8	24.9	4	194	7	27.7
Environmental Science	12	411	23	17.9	12	331	21	15.8
Chemistry	17	762	48	15.9	14	688	40	17.2
AP Chemistry	2	54	3	18	4	54	3	18
Other	18	401	27	14.9	16	367	23	16
TOTAL	**158**	**6964**	**407**	**17.1**	**162**	**7073**	**395**	**17.9**

Note: Teachers teach more than one course therefore the number of courses will not sum to the number of teachers responding to the question (113).

The "Other" category includes 5 Physics courses each semester. Note also the 19 teachers who taught biotechnology in a chemistry class. **These teachers could be a resource to the program to develop new curricula for chemistry classes.**

Teachers are more likely to increase their teaching of biotechnology in the year immediately after their training. There is only a slight change in teaching about the use of biotechnology-related equipment this year (5%) in those from Cohort One but a substantial average change (21%) for those trained in Cohort Two. As seen in Tables 6 and 7, Cohort Two teachers taught about 5 times as many students in about 2 times as many courses as those from Cohort 1 (averages to 54 students per course v. 23 students per course.

Table 6: First Semester Courses and Sections Taught and Students Reached by Time of Initial Training

	Time of Initial BioTeach Training								
	Never trained			Summer 2005			Summer 2006		
Course	Classes	Sections	Students	Classes	Sections	Students	Classes	Sections	Students
Intro Biology	5	16	147	17	40	572	44	157	3255
AP Biology	1	1	18	7	8	88	9	11	148
Biotechnology	0			3	13	15	4	8	129
Anatomy	2	3	46	2	4	38	11	19	357
Forensics	0			3	6	33	6	12	291
Marine Science	0			2	1	28	5	7	171
Environmental Science	2	2	73	4	4	38	7	17	300
Chemistry	0			9	21	232	10	27	530
AP Chemistry	1	1	18	1	1	23	1	1	13
Other	2	6	73	6	10	115	4	11	213
Total	**13**	**29**	**375**	**54**	**108**	**1182**	**101**	**270**	**5407**

Note**:** Class totals exceed the number of BioTeach participants because teachers could indicate several courses.

Table 7: Second Semester Courses and Sections Taught and Students Reached by Time of Initial Training

	Time of Initial BioTeach Training								
	Never trained			Summer 2005			Summer 2006		
Course	Classes	Sections	Students	Classes	Sections	Students	Classes	Sections	Students
Intro Biology	5	15	147	20	52	705	47	162	3454
AP Biology	1	1	18	7	7	88	6	7	97
Biotechnology	1	1	13	3	10	15	3	7	116
Anatomy	1	2	23	2		38	10	18	339
Forensics	1	1	13	2	3	28	9	15	345
Marine Science	0			1		23	5	7	171
Environmental Science	2	2	68	3	3	23	7	16	240
Chemistry	0			5	11	131	10	29	557
AP Chemistry	1	1	18	1	1	23	1	1	13
Other	2	3	36	5	9	110	4	11	221
Total	**14**	**26**	**336**	**49**	**96**	**1184**	**102**	**273**	**5553**

Note: Class totals exceed the number of BioTeach participants because teachers could indicate several courses.

Like last year, teachers from both Cohorts reported using the DNA Fingerprinting lab most frequently (39%) as shown in Table 8. Very few teachers (7 and 6—less than 10%) in both Cohorts used the PCR or MiniPrep labs despite their inclusion in the Winter Workshop and Cohort One Summer training. While they were rated highly they have been excluded from the Table 8 because their small response rate is not comparable with those for the remaining labs.

Table 8: BioTeach labs taught September 2006- May 2007

Labs Taught	All Participants		Trained 2006		Trained 2005		Not Trained	
Did not teach any labs	50	43%	29	41%	14	41%	7	70%
DNA Fingerprinting	45	39%	26	37%	17	50%	2	20%
Transformation	33	28%	22	31%	10	29%	1	10%
Crooked Cell	23	20%	16	23%	5	15%	2	20%

Note: Teachers could select all labs that they taught so the number of participants teaching all labs will not add up to 113.

When teachers taught the labs they rated their impact highly. Teachers rated on a 5-point scale (1=Not at all; 2=A little bit; 3=Moderately; 4=Quite a bit; 5=Extensively) how well a lab addressed five criteria. Ratings, both individually and as a group, were quite high on all five criteria, with overall average ratings ranging from 3.79 to 4.15 out of 5. Refer to Table 9 for average ratings and percent of teachers rating each lab at 3 (moderate impact) or higher.

Table 9: Rating of several criteria relevant to BioTeach labs

	BioTeach Lab Rated							
	All Labs		DNA Fingerprinting		Transformation		Crooked Cell	
Number of Respondents	61		30		15		12	
Criteria	Mean	% at 3+	Mean	% at 3+	Mean	% at 3+	Mean	% at 3+
Matched Goals	4.15	100%	4.20	100%	4.20	100%	3.83	100%
Appropriate Level	4.11	98%	4.17	100%	4.13	93%	3.83	100%
Interesting	4.05	100%	4.07	100%	4.07	100%	3.83	100%
Connected	3.80	92%	3.67	87%	3.93	100%	3.67	92%
Graduation Requirements	3.79	92%	3.57	87%	4.13	100%	3.58	92%

Note: Percent at 3+ is the percentage of teachers saying labs met the criteria Moderately (3), Quite a bit (4), or Extensively (5).

A few teachers rated the DNA Fingerprinting and Crooked Cell labs slightly lower in being "connected to the rest of the course" and "helping students meet school/ state graduation requirements." Overall, these ratings are roughly the same as the comparable ratings for last year.

Teachers also rated why they wanted students to be exposed to BioTeach labs. Knowing what teachers want students to get out of the labs can inform the way they are presented in the training or revised to meet teacher needs. While most teachers considered all of the goals found in Table 10 to be important, wanting students to "learn how to interpret data" or "learn how science helps people in the real world" were most frequently rated "important" or "very important", a four (4) or five (5) on a scale of 1-not important to 5-very important. Note that the very small number of teachers reporting on the MiniPrep and PCR labs makes these numbers not comparable to the others and these two labs were not included in Table 10.

Table 10: Rating of the importance of various goals in teaching labs to students

	All Labs		BioTeach Lab Rated: DNA Fingerprinting		Transformation		Crooked Cell	
Number of respondents	**61**		**30**		**15**		**12**	
Goals	**Mean**	**Pct 4+**	**Mean**	**Pct 4+**	**Mean**	**Pct 4+**	**Mean**	**Pct 4+**
Interpret Data	4.70	95%	4.73	93%	4.73	100%	4.58	92%
Science in the Real World	4.70	95%	4.83	97%	4.47	93%	4.67	92%
Learn Science Concepts	4.36	84%	4.37	87%	4.47	87%	4.08	67%
Learn Lab Techniques	4.07	77%	3.93	73%	4.33	87%	3.75	67%

Note: Percent at 4+ is the percentage of teachers saying each goal is an Important (4), or Very Important (5) reason for teaching a lab.

Last year "learning lab techniques such as centrifuging, culturing bacteria, performing electrophoresis" was the second most important goal, but this year "learning lab techniques" is considered less important overall than the other goals, and this difference is statistically significant ($t>2.71$, $df=60$, $p<.01$). In particular, lab techniques are a less important goal in the DNA Fingerprinting lab. Learning science concepts is also seen as a less important goal for the Crooked Cell lab, and this difference is also statistically significant ($t>2.60$, $df=11$, $p<.03$). **As the program evolves it should not lose sight of the fact that teachers have goals other than improving scientific technique for their students.**

Overall, 49% of the labs rated were integrated into regular level classes, 42% were used in Advanced/ Honors/AP level courses and 9% in Vocational level courses. **This is a shift from last year's findings, where 31% of labs rated were general or integrated science levels and 50% were AP/Honors level and 13% were vocational. This may mean Biotechnology instruction is being introduced more broadly across student ability levels in a school.**

Pre-Labs

A change in the training and in the resource binder each participating teacher receives was the addition of pre-lab activities for each wet lab. These introduced concepts, outlined the relevance of the lab to daily life, and/or provided mini-lessons on key skills. This change was another attempt to help teachers better integrate biotechnology techniques into the conceptual framework of a high school science class. As an example, *Entangled in the Web* uses multiple activity centers, videos, posters, and readings to help students learn a definition of biotechnology and understand how biotechnologists can apply their understanding of bacterial transformation to produce a substance useful for humans (spider silk for use in military flak jackets and other places).

In Table 11, teachers report that nearly half (44%) use the Basic lab skills/ Micropipette Challenge pre-lab with students, with more than 20% using the Crown Jewels and Crooked Cell pre-labs. While the micropipette challenge is purely technical, the other two pre-labs are more conceptual with goals of educating students who can identify a need for DNA restriction analysis and construct a theory of how a disease works. The use of pre-labs did not seem to differ substantially depending on when teachers were initially trained. 35% of respondents didn't use any of the pre-labs. **It seems the development of pre-labs was useful to a majority of teachers responding and may help explain the increased rate of implementation this year.**

Table 11: Pre-labs taught by participants

	Time of Training							
Pre-Labs Taught	**All participants**		**Trained 2006**		**Trained 2005**		**Not Trained**	
Basic lab skills/ Micropipette challenge	51	44%	32	45%	17	50%	2	20%
Case of the Crown Jewels	34	29%	24	34%	9	26%	1	10%
Mystery of the Crooked Cell	24	21%	16	23%	6	18%	2	20%
Entangled in the Web	13	11%	9	13%	4	12%	0	0%
Did not teach any	41	35%	22	31%	13	38%	6	60%

Note: Totals sum to more than 100% because teachers may have taught several pre-labs.

Challenges to Integrating Labs

Last year 75% of respondents reported that by late Spring, they had not taught even one lab. This year, even with the reported increases in lab use, 50 (43%) respondents said they did not teach any of the five labs from the Summer training. However 19 of the 50 said they taught other (non-BioTeach) biotechnology labs, and 5% said they did not teach students this year (department administrators) leaving 23% of respondents reporting that they did not teach any biotechnology. Refer to table XX for a summary of non-BioTeach lab topics.

Table 12: Participants' list of other biotechnology labs taught this year

Labs	Description	Number of Responses	Percentage of Responses
DNA isolation	Methods other than mini-prep	13	37%
Plasmid labs	Restriction enzymes, transformation	10	29%
DNA fingerprinting	From another vendor	4	11%
Protein labs	Purification, electrophoresis, assays	3	9%
PCR	From another vendor	3	9%
Basic biotech lab skills	Micropipetting, electrophoresis	2	6%
Total		**35**	**100%**

Note: Participants (N=50) could check "other" without offering any detail so the number of individuals (17) reporting one or more detailed responses (35) does not equal the number of participants (19) checking "other".

Of the 50 teachers reporting they did not teach a summer lab, the most frequently chosen explanation (26%) was they "couldn't see how to make time for the labs with MCAS pressures". They are still having difficulties fitting the labs in with the numerous required topics in their curricula, and/or understanding how a BioTeach lab can help students prepare for or pass the state test. Variations on this theme appear across surveys, observations, and site visits to schools: a few samples from the recent survey appear below to highlight the wide-reaching impact of state standards and testing.

> *I am the Dept. Chair and the contact person for this grant…I strongly believe that the reason why the teachers did not use the equipment is because they have all they can do to get students prepared for the MCAS without adding additional content for them to teach. It was a bad move on administration's part to make these teachers responsible for teaching biotech as well.*

> *There needs to be a better link between the biotechnology concepts and the Biology Learning standards....we just barely get through the required learning standards!!!!!!!!*

> *Biotech companies need to exert their collective influence making sure that specific skills and concepts that are essential to biotechnology are in the Mass State Frameworks. The current language only peripherally suggests that teachers include biotech in lessons as is deemed appropriate - almost as an enrichment to the course….*

A minority reported needing more training to feel confident. It is clear most teachers feel technically prepared to implement the labs and use the equipment. **The program needs to link these labs (or others that are more appropriate) more closely to state standards so it can help teachers increase student exposure to biotechnology**. See Table 13 for all the reasons participants gave as challenges or impediments to implementing biotechnology labs.

Table 13: Participant reasons for not teaching a BioTeach lab this year

			Time of BioTeach Training					
Reasons for not teaching	**All Participants**		**Trained 2006**		**Trained 2005**		**Never trained**	
I can't see how to make time for it with MCAS pressures	13	26%	10	34%	3	21%	0	0%
I teach classes that don't really relate to biotech	8	16%	2	7%	5	36%	1	14%
Biotech concepts are too hard for my students	6	12%	5	17%	1	7%	0	0%
Not teaching students this year	5	10%	3	10%	2	14%	0	0%
I have other labs on these topics that I like better	5	10%	3	10%	1	7%	1	14%
I need more training to feel confident	4	8%	3	10%	1	7%	0	0%
The equipment is too hard to use with my students	3	6%	2	7%	1	7%	0	0%
Other reasons	25	50%	16	55%	4	29%	5	71%
No reason given	2	4%	0	0%	2	14%	0	0%

Note: Numbers total more than 50 because people could give multiple reasons.

Twenty-five teachers said various reasons not listed on our survey explained why they did not teach the labs, including 30% (15) who *only* gave these other reasons. From Table 14 we can see a reoccurrence of logistical issues raised last year such as large class size, poor school facilities, or inadequate kit materials summarized by one teacher like this:

Also we need a better lab! if you've ever tried Biorads' labs for these concepts, they absolutely crush those that Wards or whoever we have as a vendor is sending us, Biorads' labs are awesome! And they come with enough materials in the vials. I had a terrible time getting the students to be able to get the volumes required for the lab from the samples given…

Issues such as this are still hindering teachers from using the grant as planned with students.

Table 14: Participants "other" reasons for not teaching or planning to teach the labs

Themes	Definition	Number if Responses	Percentage of Responses
Timing	Lab materials arrived too late to fit into curriculum	5	23%
Time	Too little prep time and insufficient flexibility in semester schedule	5	23%
Class size	Class size too large to accommodate hands-on labs	3	14%
Alternate use	Using materials for different types of labs	2	9%
Funding	Insufficient funds to purchase lab materials	2	9%
Alternate facility	Brought students to City Lab, Harvard, or MIT	2	9%
Curriculum integration	Insufficient connections to core concepts and state standards	2	9%
Alternate implementation	Teaches labs as demonstrations	1	5%
Total		**22**	**100%**

Note: Participants (N=25) could check "other" without offering any detail so the number of responses does not equal the number of participants.

Detailed discussion of the challenges came from interviews with teachers and administrators at seven (7) Cohort One and seven (7) Cohort Two schools. The interviews support themes identified in Table XX, especially the mismatch between the goals of the labs and the goals of each science course, the lack of coordination between typical class period lengths and the lengths of the labs, and late (December) equipment arrival. Refer to Quarterly Report Seven for more details about these challenges.

Impact of Program on Students

Without testing students, the evaluation relied on teacher report of student gains to understand the impact of the grant on students. Table 15 summarizes teacher ratings of the impact of BioTeach labs on students at regular, advanced, and AP course levels according to a number of criteria: student awareness of biotechnology, student understanding of the uses of science in the real world, student level of interest/ engagement, student learning of biology, chemistry or another science, and student learning about careers in science industries. Ratings were on a 5-point scale (1=Not much; 2=A little; 3=Moderate; 4=Quite a bit; 5=Extensive) and teachers not teaching at a particular level could say the question was not appropriate to their experience.

Table 15: Teachers' ratings of BioTeach's impact on students at different course levels

Impact on…	All Course Levels	Regular	Advanced	AP
Student interest/engagement	3.96	3.84	4.06	4.18
Student understanding of the uses of science in the real world	3.60	3.44	3.77	3.94
Helped students learn biology, chemistry or another science	3.51	3.30	3.74	3.85
Student awareness of biotechnology	3.49	3.27	3.74	3.97
Helped students learn about careers in science industries	3.29	3.15	3.33	3.56

Note: Double check this

BioTeach teachers observed that biotechnology lessons have had the most impact on students' interest and engagement in class[4] with somewhat less impact on students' understanding of the uses of science in the real world, their learning of science concepts or skills, and their awareness of biotechnology, and the least impact (but still a moderate amount) on students' learning about careers in science industries. Across all criteria, the impact is greatest in AP classes, somewhat less in Advanced classes, and least in Regular level classes.[5]

In open-ended comments, teachers were much more positive than negative about using a BioTeach lab with students. A summary of their comments can be found in Table 16.

[4] Differences between the mean and those of other criteria ≥ .36, t ≥ 3.19, df ≥ 92, p<.002

[5] The differences in ratings of impact between AP and Regular classes are statistically significant for each of these five criteria (differences ≥ .29, t ≥ 2.12, df ≥ 27, p<.05). The differences in ratings of impact between Regular and Advanced classes are statistically significant except for "Student interest and engagement" (differences ≥ .32, t ≥ 2.68, df ≥ 46, p<.01). Comparing Advanced and AP classes, only the difference in "Student awareness about biotechnology" is statistically significant (difference = .27, t=2.28, df=29, p=.03).

Table 16: Participants additional comments about student impact.

Themes	Definition	Number of Responses	Percentage of Responses
	Positive Impact		
Hands-on	Ability to teach additional hands-on labs increased students interest	8	26%
Authentic context	"Real life" connections engaged students	6	19%
Student level	Impact was primarily on AP and advanced students	6	19%
Total		**20**	**65%**
	Negative impact		
Facilities and logistics	Space, prep time, and kit ordering issues reduced implementation and student impact	6	19%
Student Level	Labs are too advanced or not engaging for low level students	3	10%
Curriculum integration	Semester timing and MCAS pressure reduced implementation and student impact	1	3%
Kit quality	Problems with kit design and reliability meant teachers unwilling to do with students	1	3%
Total		**11**	**35%**

Data from the site interviews with seven Cohort One and seven Cohort Two schools supports this positive view. Almost all teachers (36) and department chairs (10) interviewed perceived the BioTeach program as having a positive impact. On a scale from 1 (not at all) to 5 (to a great extent), department chairs at the mid-year mark (January) reported the program was having an average impact of 3.0 on students in lower level science courses and 3.4 on students in high-level science courses. The majority of teachers interviewed perceive the program as increasing the amount of hands-on lab work in biotechnology for all student levels as well as increasing the quality of the work they can do with students, particularly with lower level students. Two teachers ended their surveys with the following comments similar to the majority of opinions expressed in site interviews

> *The equipment is wonderful. The lab ideas are wonderful as well.*
>
> *The BioTeach program has been a huge support for the science program at our school. The grant money was essential in establishing a biotechnology component at our school.*

Equipment

Measuring what teachers use and don't use with students is one gauge of the extent to which Biotechnology is being taught in schools. This year, more teachers reported teaching students how to use the equipment. This can be best seen by noticing which equipment they don't use with students. Table 17 shows change in teachers not teaching individual pieces of equipment associated with the labs in summer training. The most noteable improvement is the 25% change since last year in the use of micropipettes and a

21% change in the use of gel electrophoresis boxes. Like last year, the least amount of change was reported in the use of the balance, washing glassware, and sterile technique.

Table 17: Number of classes to whom teachers taught the use of equipment introduced during summer training and the percent of teachers reporting they never taught about that equipment to students.

	This Year		Last Year		Change	
Equipment	**Mean**	**Pct Not Taught**	**Mean**	**Pct Not Taught**	**Increase in Mean**	**Decrease in Pct Not Taught**
Micropipette	1.88	27%	1.47	52%	0.41	25%
Gel Electrophoresis	1.66	32%	1.24	53%	0.42	21%
Vortex	0.98	59%	0.77	73%	0.21	14%
Centrifuge	1.35	46%	1.13	59%	0.22	13%
Serological Pipette	1.28	49%	1.13	61%	0.15	12%
Sterile Technique	1.51	37%	1.34	46%	0.17	9%
Glassware	2.01	32%	1.94	37%	0.07	5%
Balance	2.79	11%	2.71	14%	0.08	3%
Average	**1.68**	**37%**	**1.47**	**49%**	**0.22**	**13%**

Note: Increase in mean or decrease in percent not taught means improvement.

Teachers reported that equipment, separate from solutions, DNA samples, and other consumables packaged as Kits, contributed to improvements in their teaching of science and biotechnology at the moderate level, 3.21 on a 5-point scale (1=Not at all; 2=A little; 3=Moderate; 4=Quite a bit; 5=Extensive). They reported a slightly greater impact on teaching across their department. Refer to Table 18 for the mean rating for each of these program aspects and the percentage of teachers saying this program aspect had a "moderate" (3 rating) or greater impact on their teaching or on the department.

Table 18: Rating of program impact on teaching and the department

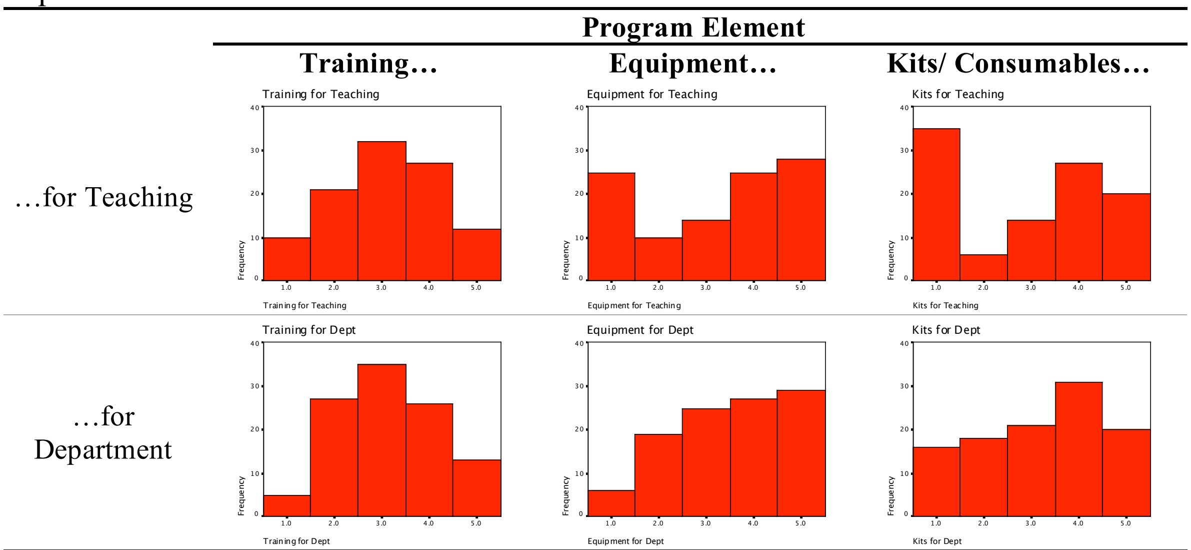
	Impact of BioTeach Program			
	…for Teaching		**…for Department**	
	Mean	**% at 3+**	**Mean**	**% at 3+**
BioTeach Training contributes to improvements in your teaching of science and/or biotechnology	3.10	70%	3.14	70%
Equipment purchased via BioTeach contributes to improvements in your teaching of science and/or biotechnology	3.21	66%	3.51	76%
Kits purchased via BioTeach contribute to your improved teaching of science or biotechnology	2.91	60%	3.20	68%

Note: There were 102 teachers who rated the impact on their teaching and 106 who rated the impact on the department as a whole.

These ratings of impact on teaching were comparable or slightly higher than the ratings last year.

Although the average ratings are "moderate" there is a lot of variation in teachers' ratings of these program aspects, with substantial numbers of teachers saying the program had "none" or just "a little " of impact, especially on their own teaching. The graphs in Figure 19 show this variation. The columns, reading from left to right, show the numbers rating each question: "Not at all", "A little", "Moderately", "Quite a bit", "Extensively". Teachers' ratings of the differing levels of impact indicate the difficulty of designing one program for all teachers regardless of needs or teaching environments.

Figure 19: Distribution of the impact of BioTeach program elements on teaching and the department



Note: The y-axis on all these graphs ranges from 0 to 40 with marks every 10.

By looking at those who participated in the evaluation this year but who *didn't* respond to surveys last year we can estimate the impact of the program as a whole, rather than just on the teachers who agreed to be part of the evaluation. The idea is that teachers who responded this year but not last year from Cohort One may be more like those who *didn't* participate in the evaluation at all or who didn't respond this year from Cohort Two, than are those who have participated in evaluation all along the way. If it turns out that these Cohort One teachers are not that different from those who participated in the evaluation all along, then we can cautiously generalize about the program's impact on all participants.

There were 34 people in the current sample who attended training in 2005, 16 also responded to the survey last year ("Repeat respondents"), and 18 did not ("New respondents"). For the most part, responses from the New respondents are no different from responses from the Repeat respondents. Thus, we find that those who didn't participate in the evaluation last year are quite similar to those who did. In most respects we can cautiously assume that the non-responders in Cohort One and two are experiencing the same success and challenges with the program.

However there are a small number of areas in which the New responders are different enough from the Repeat responders that this difference can't just be attributed to chance fluctuations. Particularly, teachers who didn't respond last year but did respond this year seem to be slower in implementing various components of the program than their counterparts. This may also be reflected in their slightly higher need for training. Also New responders' report somewhat lower ratings of the impact of the program on students and of the importance of the four goals (learn lab techniques, learn science concepts, learn how to interpret data, and learn how science helps people in the real world) suggest that they haven't bought into the purposes of the program as strongly, nor do they see it as important or effective.

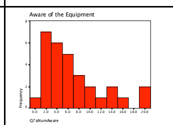
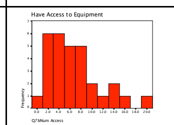
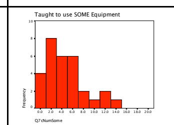
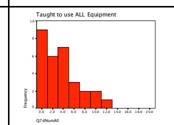
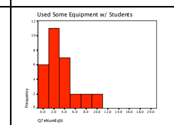
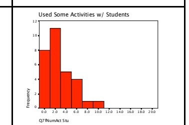
Teachers overall are more likely to increase their teaching of the use of these biotechnology-specific pieces of equipment in the year immediately after their training. There is only a slight change (5%) in those from Cohort One but a substantial average change (21%) for those trained in Cohort Two.

Impact on Science Department

A key program goal is to have biotechnology lessons and concepts present in each school. This can best be observed by looking into the amount of transfer from teachers who attended the training to teachers who did not attend the training as one or even two trained teachers per school does not guarantee program sustainability over six years.

Like last year, department chairs (34) reported that informal dissemination activities such as telling teachers about the equipment were more widespread than those that required additional structure, time and engagement such as teaching others how to use the equipment. The figure below shows the average number of teachers and the distribution of responses for six different types of department engagement. Chairs were asked "Of those science teachers in your school who did not attend the BioTeach summer training, how many are 1) aware of the equipment, 2) have access to it, 3) have been taught to use some of the equipment, 4) have been taught to use all of the equipment, 5) have used the equipment with students, 6) have used the activities with students. The left-most bars start at zero teachers and progress sequentially up to the right most bars ending with the largest departments of 18 teachers. This clustering of bars to the left for none to low numbers of teachers, indicates again, that most teachers and department chairs were casually communicating about the program but not undertaking a more focused effort to share what they knew with the department. Indeed eight department chairs (24%) reported that no other teachers had used at least some of the equipment with students. This limited dissemination poses a risk for BioTeach because if a teacher leaves, as 20% do every year, or develops other priorities, the equipment does not get used, students don't get exposed and the biotechnology "seed" planted in the school can die.

Figure 20: Dissemination from trained teachers to untrained teachers

	Spread of BioTeach	Aware of equipment	Have access to equipment	Taught to use SOME equipment	Taught to use all equipment	Used equipment w/ students	Used activities w/ students
This Year	Mean (SD)	6.47 (5.62)	6.23 (4.87)	4.13 (3.62)	3.03 (3.25)	2.83 (2.81)	2.40 (2.46)
	Mini Graphs						
Last Year	Mean (SD)	6.14 (4.76)	5.52 (4.40)	3.10 (3.85)	2.40 (3.86)	1.55 (1.23)	1.45 (1.28)

The program should consider how it can create opportunities for trained teachers to share what they have learned with other teachers in their departments.

Despite the lack of sharing of program training and resources in some departments, trained teachers seem to be using the resources more with students this year than last year. An increase in percent of students using wet labs is apparent at both regular and advanced levels in Table 21.

Table 21: Percent of students experiencing any wet labs

Level of Biology Courses	Percent of students using wet labs Last year	Percent of students using wet labs This year
Regular Biology	53% (41)	69% (36)
Advanced Biology	57% (47)	67% (45)

Note: Increase in regular biology class is statistically significant (t=2.88, df=28, p=.008)

While the increase in percent of students using wet labs is statistically significant, much of this increase can be accounted for by a few schools (3-6 for regular level courses, and 3 for advanced levels) dramatically increasing wet lab use while the majority of schools report delivering about the same percent of wet labs to students as last year. This may indicate that some schools are more able to take advantage of the grant seed money and resources where others are in more challenging situations. **It may also be an opportunity for the program to direct resources towards those kinds of schools that are likely to take advantage of the program and report dramatic impact. Further analysis might clarify the characteristics of these schools.**

As another measure of department level impact, administrators reported the amount of school funds (not grant funds) used to purchase biology lab consumables and equipment for 2006-07. This amount ranged widely from $0 to $30,000, with a mean of $3,747 with one standard deviation range going from $1,439-$9,750.[6] These amounts are all

[6] This range is not evenly distributed around the mean because we used a statistical adjustment to deal with the skewness of the data, and then transformed the results back to their natural units to report here.

somewhat higher than last year and may indicate that departments are finding the wet lab experiences valuable for students and are willing to commit funds to support them.

Participant Ideas for Support

Teachers rated suggestions for additional training they might need in order to teach more biotechnology activities on a 4-point scale (1=Do not need; 2=Need somewhat; 3=Need; 4=Really need). Half or more of teachers said they "needed" or "really needed" training to "learn about non-lab biotechnology activities", "to develop more lab activities for the equipment", "to learn about careers in the science that might interest students", and "to develop a biotechnology course for high school". Table 22 shows the average ratings for each of these items, and the percent of teachers (N=107) saying they "need" or "really need" such training, ordered from highest to lowest need compared to responses to a similar question about interest last year.

Table 22: Participant ratings of their needs in order to teach more biotechnology

	This Year		Last Year	
Additional Training	**Mean**	**Percent Need/Really Need**	**Mean**	**Percent Interested/Very Interested**
Learn about non-lab biotechnology activities such as computer simulations or videos	2.59	62%		
How to develop more lab activities for the equipment we ordered	2.57	58%		
Learn about careers in the sciences that might interest students	2.49	55%	2.82	67%
How to develop a biotechnology or forensics course for high school	2.49	53%		
How to relate biotechnology topics to real life	2.31	45%		
How to refocus labs to emphasize core science concepts	2.28	44%	2.59	59%
How to develop student ability to interpret data from labs	2.26	40%	2.46	49%
How to use the new equipment	1.91	28%		
Other (N=76)	2.1	41%		

Note the request to learn about non-lab activities. The request for information about careers in the sciences was also strong last year. Several teachers wrote more extensively about careers in the "Other" section, summarized in Table 23. One teacher articulated his ideas about career information this way:

If you want more kids in the biotech pipeline, create internships at Biogen, Genzyme, Millipore, Astra-Zenica, etc. working on real research projects. There are a few places which do this now (mostly the hospitals and med. schools), but I probably have 10 - 15 students scrapping for what will turn out to be <5 places. If you can hook them as sophomores, you'll keep a lot of them, and you will supercharge the science programs in the schools. Right now, the incentive for doing the tons of extra work that an AP science requires above other HS courses is a slightly better entrance on your transcript and *maybe a small edge in college admissions (offset by the risk of getting a bad grade in such a difficult course). If it gave you a good shot at an interesting summer job AND a leg up on college admissions (because you might already be published), we'd be beating them away w/ sticks. Even if the internships were unpaid, they would have a big impact on our programs, but I think that the ROI on paid internships would be much higher than anything that is happening now.*

Table 23: Participants "other" needs in order to teach biotechnology

Needs	Definition	Number of Responses	Percentage of Responses
More time	Semester schedule flexibility, prep time too much, lab time too long	4	22%
Better BioTeach Kits	Kit quality insufficient and ordering logistics still not timely	3	17%
Clearer links to department foci	Better connections to standards, issues with priority of labs over other dept. priorities	3	17%
Additional training	On lab adaptation, equipment use, curriculum integration	3	17%
Connections to Biotech Industry	Stronger program connections, or introduction	2	11%
School support	Need more administration/department level implementation support	2	11%
Ongoing funding		1	6%
Total		**18**	**100%**

A minority said they needed additional training about how to use the new equipment.

A small but highly vocal percentage of site interview participants (6 of 14) confirmed during site interviews that they see MassBioEd as "all things Biotechnology" and not just a wet lab program. In poorer districts, teachers do not have the actual rooms available to make use of lab equipment: they do not have outlets, they do not have enough lab benches for students to use, they do not have sinks or eye wash stations, and they are looking to the program for some other way to introduce the field to their students. More sophisticated schools with younger faculty or those from the industry identified that they need a broader array of labs to work with: the labs are focused around similar aspects of the field. Vocational schools, and more suburban schools asked for career information. In addition, a substantial minority (41%) said they needed support on other topics not listed on the survey.

Life Science Career Development Pilot

Career development has been an important component of the BioTeach design. To determine what types of educator and student career development activities would be most effective, BioTeach, the Metro Southwest Regional Employment Board (MSWREB), and the Massachusetts Department of Education staff developed a Life

Science Career Development (LSCD) pilot. Phase one of the pilot began in the 2005-06 academic year when six teams of educators participated in biotechnology career awareness activities. Building upon these activities, the goal for phase two was "…to develop a school-based, sustainable collaborative leadership model that supports the development of Academic, Personal and Employability skills of students thereby increasing the number of students pursuing Life Science and Biotechnology majors at the post secondary level," (BioTeach LSCD application, 2006).

LSCD Evaluation Design

Through this part of the evaluation, BioTeach staff hoped to identify the most effective aspects of the pilot that could be realistically implemented with more schools in a cohort. Based on stated priorities from BioTeach, measures tried to capture:

- increases in biotechnology career knowledge and collaboration for teachers, guidance counselors, and administrators
- participation in and learning from career development activities for students.

Information about instrumentation and data collection can be found in Appendix A.

Participants and Supports

Five teams who participated in year one of LSCD along with one new team submitted applications to participate in the initiative during 2006-07. All were accepted. Each comprised 5-7 members that included guidance counselors, science teachers (some of whom participated in BioTeach summer training), and administrators. Although conceived as a full academic year program, it took longer than expected to begin. Therefore, the schedule was somewhat condensed and the program ran from December 2006-May 2007.

As they developed their knowledge and planned career development activities for students, the teams were supported in the following ways:

- Five of the six teams had support from the Career Specialists assigned to their schools through their Regional Employment Boards. The Career Specialists provided administrative/logistical support and had experience with planning career activities.
- Two LSCD events were offered. In December 2006, teams had an opportunity to learn about biotechnology careers via a presentation at Genzyme and participated in a workshop where they could explore team-building and discuss how they would engage in collaborative work during the rest of the year. In May 2007, teams heard presentations about biotechnology efforts at Astra-Zeneca from two scientists and then presented to each other the work they had done in their schools with their students. About 80% of team members came to each workshop.
- The project director from the MSWREB conducted two workshops with the career specialists and some guidance counselors on the biotechnology industry on specific career opportunities within the industry.

- A veteran guidance department chair offered two special professional development sessions for guidance counselors. One focused on the Massachusetts Counseling model and the expanding role of guidance in their teams and in their schools. The second focused on helping counselors learn how to gather, analyze, and use data in decision-making.

While each team was expected to recruit and sustain a cohort of younger high school students and to develop and implement career awareness activities for them, the work process was not prescribed. Each team established its own goals and handled planning, meetings, outreach, etc. More information about the planning and service delivery as well as team reflections will be provided in Team evaluation reports. (KATE: As of this date, these are still outstanding.)

Biotechnology Career Knowledge

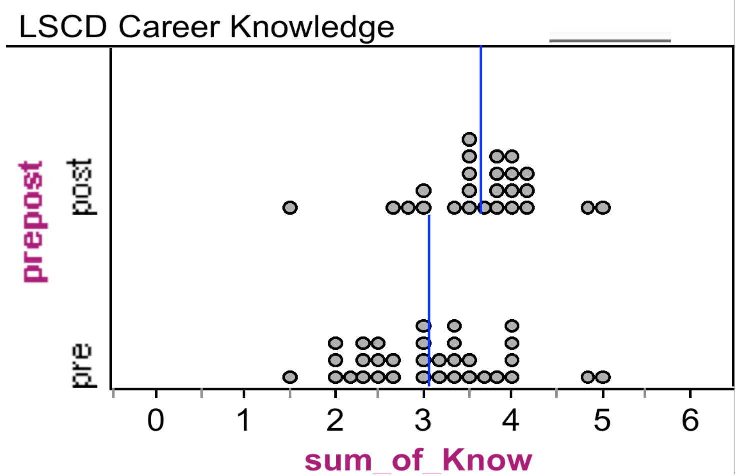
The following evaluation questions reflect the priorities of program staff and guided the evaluation in this area:

- To what extent and in what ways do teachers and guidance counselors learn more about biotechnology educational requirements and career opportunities?
- What, if anything, interfered with developing career knowledge?

Initial expectations: Based on initial survey data, most team members entered the pilot hoping to learn more about education requirements for various kinds of positions in biotechnology. While many were interested in learning about the industry in general, some wished to know about specific aspects such as bioengineering, forensics, veterinary technology, cytology, genetic counseling, cancer treatments, bioinformatics, and environmental applications. Some hoped to look very closely at their curriculum to see how they could/could not integrate biotechnology. Other members wanted immediate assistance with finding biotechnology internships for high school students and job opportunities for those who were not going on to higher education immediately.

Findings: Comparisons of pre- and post-survey data from teams suggest that, overall, participants' initial expectations for learning were fulfilled. The dots on Figure 24 represent each participant's average score across six biotechnology career knowledge items, where 1 indicates “no knowledge” and 5 indicates “very knowledgeable." There are more dots at the lower left end of the pre-survey graph as compared with the post survey graph, and the blue lines show the overall mean increases from 3.08 to 3.65. This positive change is statistically significant ($t= 2.84$, $df=55$, $p<.01$)

Figure 24: Overall Change in Teacher Ratings of Biotechnology Career Knowledge



Disaggregated data about each item for Career Knowledge appears in Table 25 and show statistically significant increases in team member responses to five of the six biotechnology career items. On average, team members felt their knowledge increased in all areas except about high school requirements for a 4-year science/biotechnology program. Given that understanding four-year college requirements has been the traditional focus of guidance counselors and some teachers, there may have been less need to develop knowledge in this area.

When asked what interfered with their learning, team members most frequently cited time (both on their survey and in their final presentations). In particular, having responsibility for a large number of students and/or a large workload and a rigid schedule that was constraining were the typical culprits. Some mentioned budget challenges and the amount of information they needed to learn in a short time as interfering factors. A few team members found that nothing interfered.

Table 25: Biotechnology career knowledge items

ITEM	Pre-Survey Mean	Post-Survey Mean	Mean Difference	SE Difference
High school requirements for a 4 year science/biotech program	3.2	3.3	.1	0.355
Range of jobs available for high school graduates in most biotechnology companies	3.1	3.6	.5*	0.327
Opportunities available in the in the biotechnology field for graduates of 2 year college science/biotechnology programs.	3.0	3.5	.5*	0.318
Opportunities available in the biotechnology field for graduate of 4 year college science programs	3.5	4.0	.5*	0.278
High school requirements for biotechnology work directly after high school	2.7	3.6	.9***	0.350
High school requirements for a 2 year science/biotech program	2.9	3.8	.9***	0.324

Note: *indicates significance where p<.05, **indicates significance where p<.01, ***indicates significance where p<.001.

Kate we need to double check the SE difference

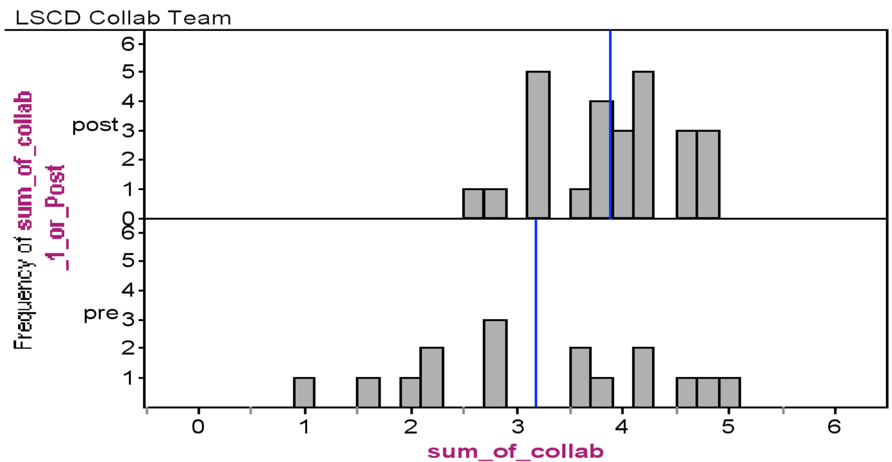
Collaboration

The following evaluation questions reflect the priorities of program staff and guided the evaluation in this area:

- To what extent do guidance counselors and science teachers share their knowledge and perspectives during team meetings and LSCD activities?
- What are the team members' contributions to activities?
- What, if anything, interfered with collaboration?

Findings about team collaboration: On average, participants indicated that their team collaboration contributed more positively to their LSCD work this year as compared with last year. As shown in Figure 26, the average (blue vertical line) for all team collaboration items on the pre-survey was 3.17 and increased to 3.88 on the post survey where 1 indicates “not at all” and 5 indicates “to a great extent." This positive change is statistically significant (t= 2.2, df=20, p<.05).

Figure 26: Comparisons of team collaboration on pre- and post surveys



However not all aspects of team collaboration made a contribution. Team members indicated a greater level of sharing of knowledge and perspectives among themselves this year as compared with last ($t=2.4$, $df=22$, $p<.05$). Similarly, team members felt that they took a leadership role within the group more extensively than in the past ($t>2.4$, $df=31$, $p<.05$). Many enjoyed and appreciated a model of distributed leadership across members allowing them to share responsibilities. Other comments suggested that having a single leader to keep things coordinated and moving forward would have improved their team's work. The comments below represent generally positive feelings about collaboration across all six teams:

> *The team was professional, collaborative, and flexible. We contributed our individual and professional strengths to create a multifaceted and comprehensive experience for the students.*

> *My team works well together. Our vested interest is different because not all teachers have students in their classes that are in the [biotechnology] club here. Yet we still accomplished my goal of collaboration. We share ideas and work.*

However, team members did not indicate that collaborative work on their team allowed them to learn more about science or about career experiences for students; survey items focusing on these two areas did not show statistically significant change. Based on responses to open-ended questions and final presentations, it doesn't appear that members structured their collaborative team time to learn about science or careers. Instead, it was used to get student career activities planned and executed. Ultimately, guidance counselors and science teachers may find that the process of sharing their expertise as they planned programs for students extended their knowledge about science and/or careers, but this benefit was not evident to them immediately following the work.

Findings about collaboration outside of teamwork: In addition to collaboration within the team, there were positive, statistically significant changes in responses about collaboration between science teachers and guidance counselors outside of teamwork. Members felt that they worked together to discuss students' educational needs related to careers in science ($t=3.2$, $df=38$, $p<.01$) and to plan and implement activities to enhance student awareness and interest in science careers ($t=3.9$, $df=38$, $p<.001$) to a greater extent this year. Two participants' comments summarize the benefits of building collaborative relationships between science teachers and guidance counselor through their LSCD participation.

> *...As a result of our team's efforts, I have felt a closer, professional bond with the participating science teachers.*
>
> *Both our biotech teachers provided excellent presentations to my students. I look forward to future collaborations with those and other teachers.*

Career Development Activities

The following evaluation questions reflect the priorities of program staff and guided the evaluation in this area:

- How many students participated in career development activities and how effective were recruitment strategies?
- What type and level of communication was established between staff and parents?
- What program activities were developed for students and what interfered with the activities?
- How did the activities enhancing students' awareness of biotechnology education and careers?

Recruitment and participation: Each team recruited a cohort of younger high school students (from grade 9 or 10 grade, primarily) through personal contacts and classroom presentations. Based on team presentations and the four Activity Reports submitted, it appears that most cohorts remained stable with few students dropping out. However, not all students within a cohort attended all planned activities. Data about outreach to parents will be available when all Activity and Team Evaluation Reports are submitted.

Cohorts ranged in size from 27 to 56 students with a total of 254 participating. Information about the participating students across all six teams is detailed in Tables 27 and 28.

Table 27: LSCD student characteristics

Gender	Number
Female	142
Male	109
Unclear Response	3
Grade Level	
9th	99
10th	152
11th	3
12th	0
Ethnicity	
White/European	112
Hispanic	73
Black/African American	56
Mixed Race	28
Native Person	25

Table 28: Courses in which LSCD Students are registered or plan to register

Current science course		Science courses planning to take next year		Science course(s) planning to take before graduation		Took AP?	
Biology/Honors Bio and specialized biology courses	222	Anatomy/AP Anatomy	24	Anatomy/AP Anatomy	21	Yes	12
Biotech Academy	2	Astronomy	0	Astronomy	2	No	237
Chemistry	9	Biology/Biology 2/AP Bio	68	Biology/Biology 2/ AP Bio	32		
Health	9	Biochemistry	0	Biochemistry	1		
Physics	1	Biotech Academy	2	Biotechnology	4		
None	9	Chemistry/AP Chem	93	Chemistry/Chemistry 2	58		
		Computer Science	0	Computer Science	1		
		Earth Science/Space Science/Ecology	5	Earth Science/Ecology/ Environmental Sci	12		
		Marine Biology	1	Marine Biology	0		
		Forensic Science		Forensic Science	5		
		Health/ Health 2	4	Health and Nutrition	2		
		Life Science	1	Life Science	2		
		Oceanography	4	Oceanography	8		
		Physics/AP Physics	37	Physics/Applied Physics/AP Physics	40		
		Psychology	1	Psychology/ Social Sci	5		
		Robotics	0	Robotics	1		
		Zoology	0	Zoology	1		
		Don't Know	23	Don't Know	29		
		None	8	None	18		

Career activities for students: In both their Team Survey responses and in their final presentations, teams seemed energized and expressed pleasure at having made progress. For many of the teams, this was the first time that they implemented a more cohesive and complete set of activities. They felt they had accomplished a fair amount given the brief timeframe and the competing school events at the end of the year.

The following types of career activities were developed and implemented by some to all of the six teams. Specific information about the work of each team will be available in their Final Evaluation Reports.

1. Learning about specific biotechnology careers via:
    a. "career cruising", an interactive software program linking detailed occupation profiles with detailed post secondary databases
    b. luncheons with scientists
    c. guest speakers/panels
2. Career counseling about college and certificate programs in the life sciences and biotechnology
3. Biotechnology Field Trips
4. College visits to science programs
5. MCAS tutoring/academic support
6. Support with STEM-related course selection
7. Biotechnology lab work via after school science clubs

Although they were able to offer a suite of activities to their students, Team participants found it difficult to work with biotechnology companies in order to expand their career offerings further. Because of their association with MassBioEd many had envisioned partnering with companies to establish internships, schedule tours, and increase visits from scientists. This often did not happen and left participants both frustrated and surprised that there wasn't more support from industry. The comments from Team participants below provide examples of the activities offered and the challenges they encountered

> *We held luncheons with scientists currently in a biotechnology field so that students could learn about their work and what it took to get there. We also visited colleges in the area so that students could learn about working in a laboratory and what courses/majors the colleges offered.*
>
> *The team designed the one semester biotechnology course we are offering to students next year; the team also helped me decide who would teach the course.*
>
> *Our team had difficulty coordinating with biotech companies - especially for a site tour. Being able to visit a lab and talk with employees would be very beneficial.*
>
> *Not having scientists, chemists, etc. to speak to the student about their jobs and what it took for them to be where they are and why students should consider a career in Biotech [interfered with our planning].*

Student response to career activities: All six teams had students complete baseline surveys. Only four of the six teams had students complete final surveys in time for this report, therefore, the analysis that follows is based on only the four teams who could provide both pre and post data. Across these four teams, 157 students completed the baseline survey and 122 of these students completed the final.

In their final presentations, teams reported that students were enthusiastic about the career activities. The teams who created after school science clubs noted that students who came enjoyed the lab experience but that attendance was inconsistent. Student survey data in Table 28 confirm that some students participated in field trips, job shadowing, career days/fairs, and career days/fairs during the year, however, the full cohort of students from these four schools were not involved. Changes in the amount of pre and post student participation were not significant in the first three areas, however there was a statistically significant positive change in the number of students who reported speaking with science professionals about their careers[7]. Clearly, such things as career cruising and luncheons with scientists made an impression on students. It is also important to note that there were new types of activities for this year, most notably, visits to college science programs/events and interactions with a wider range of science professionals.

Table 28: Comparison of student participation in career activities

Activity	Pre	Post	Activity Type Pre	Activity Type Post
Science Field Trip	55%	60%	Aquarium/Museums (27) Biogen Idec (25) Biotechnology or Lab (9) City Lab (8) Other (9)	College science programs/events (23) Biogen Idec (18) Biotechnology or Lab (15) Aquarium Science Museum (8) Other (2)
Job Shadow	12%	13%	Biotech/Biomedical (23) Science Museum (10) Healthcare (9) Culinary (1)	Biotech/Biomedical (18) Healthcare (9) Science Museum (4)
Talk With Science Professionals About Their Work	44%	59%	Scientist (38) Doctor (34) Nurse (31) Researcher (22) Other (28)	Scientist (38) Researcher (21) Nurse (21) Medical Technician (16) Other (34)
Career Day/Fair	17%	19%	Biotechnology (17) Science (15) Healthcare/Medical (14) Other (4)	Biotechnology (18) Healthcare/Medical (6) Science (7) Other (3)

One other area showed significant positive change[8] as shown in Table 29. More students reported having discussions about high school requirements needed to major in a science-

[7] $\chi^2 = 5.8$, df=1, $p<.05$
[8] $\chi^2 = 12.5$, df=1, $p<.001$

related disciplines this year than last. When asked who discussed these course requirements, those who responded most frequently cited teachers and guidance counselors. A few students also mentioned that they had spoken with people from industry.

Table 29: Change in amount of discussion about required courses for science careers

		Yes	No
Has anyone discussed the required courses you will need to major in a science related discipline?	Pre	26 (16.9%)	128 (83.1%)
	Post	42 (35.6%)	76 (64.4%)

While greater participation of students in some career activities was apparent, there were no statistically significant changes in the types of resources they used, their participation in biotechnology labs or career discussions in science classes, or the number of biotechnology career discussions they had with guidance counselors. And while the awareness activities hadn't yet had an impact on student plans for higher education, there was an upward trend in the amount that students knew about STEM career opportunities. Because this trend was marginally significant, we can't be sure true change occurred. However, this may be an area to watch for positive trends in the future.

Based on this data, it appears that the second year of the pilot built upon the first, offering new opportunities for teachers, guidance counselors and students, and students. Overall, team participants continued to learn more about biotechnology careers and education requirements that would allow students to move into the field. While the actual teamwork did not contribute to their learning, it provided a positive collaborative experience that led to the development and implementation of career activities for students. It also led to increased collaboration outside of the team between these science teachers and guidance counselors. Both Team participants and students confirmed that their were new career awareness activities provided as a result of the LSCD pilot, and offerings extended into some new areas (e.g., visits to biotechnology labs in colleges). However, opportunities for students to explore and learn at biotechnology companies were still limited. Participation in these activities over the six-month period has led to few student-level changes at this point. In part, this may be due to the fact that the students are in 9th and 10th grade and aren't yet planning for post-secondary education and careers. It is likely that more sustained exposure is needed as well.

Recommendations

The introduction of Pre-Labs and other integration activities coupled with enhanced training to articulate the science content behind each lab technique seems to have increased both the use of the equipment and implementation of some of the labs with more students across both beginning and advanced levels of science.

1. Continued commitment to integration activities should benefit the program

Teachers are still finding it difficult to understand the connections between state standards and the science behind the laboratory techniques, citing lack of time due to MCAS pressure as the chief obstacle to implementing labs.

2. The program instructors can model how to analyze the data from the labs and connect this back to the standards so teachers have a clearer map of what each lab teaches students about science.

3. Instructors can inform teachers of the concept areas in which labs might be integrated, so they can deepen students understanding about the lab and determine the most effective areas in which to integrate the labs.

The program is reaching science teachers with experience teaching biology topics who leave the initial training prepared to teach some biotechnology. It does not attract all of them to the follow-up day training.

4. The program can rethink the purpose and audience for the follow-up day.

Teachers report a wide variety of school-based impediments that hinder student exposure to biotechnology wet lab activities.

5. The program should review whether it might include new resources by presenting biotechnology to teachers through other resources such as virtual online labs, video clips, and other non-lab lessons in order to reach more students and overcome school impediments.

When taught, the labs are meeting teacher goals and are having moderate or higher levels of impact on students.

6. There is room for improvement in the goal of how students learn about careers in science through the labs, especially in lower level classes. Additionally program participants need program activities for learning about and integrating career awareness with their students in science classes.

Ordering equipment has become easier and more efficient with fewer problems reported this year than last year.

7. There are still issues receiving kits and with the amount and quality of the materials in the kits that the program manager can address with the vendor.

More science students have received biotechnology instruction earlier in their school career, although teachers report slightly less impact on them than on more advanced students.

8. In all trainings, grouping teachers by level of student taught could maximize productive exchange between teachers so that they generate their own solutions to teaching beginning and more advanced science students.

BioTeach is unusual in that it endures for more than one year and operates under the conviction that teacher change will be more likely with 6 years of support. This asset should be leveraged to ensure program success.

9. Given incomplete attendance at follow-up trainings, the program should address teacher turnover (teachers leaving the program) within and between program years as well as a way to increase departmental involvement to ensure that schools maintain a minimum base of teachers in the program for 6 years.

Appendix A

Chart XX: Summary of Data Collection Instruments and Respondents

Instrument	Number of Participants	Number of Respondents	Month of Data Collection
Pre/Post training survey	105	85	July-August 06
Implementation survey (Spring)	226	113	June 07
Observation of Follow-up day	123	NA	February 07
Group interview protocol	46	46	January 07
LSCD Team pre-survey	38	35	December 06
LSCD Team post- survey	38	27	May 07
Observations of Two LSCD Events	Approx 30 at each event	N/A	Event 1-December 06 Event 2-May 07
LSCD student pre-survey	254	254	January-February 07
LSCD student post-survey	254	122	May 07
LSCD Activity Reports	6 Teams	4 Teams	May 07
Note: * = only data from 157 students in 4 schools could be used			