Teacher Training and Impact Utilizing Health Science Portable Laboratories

SEPA Phase II: A collaboration between Columbia University and the New York Hall of Science: Program Evaluation

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Executive Summary

Introduction

The goal of a two-year SEPA grant, Phase II of a collaboration between Columbia University (CU) and the New York Hall of Science (NYHoS), was to enhance science teaching and learning through the use of portable laboratories and hands-on modules to study biotechnology and microscopy in middle and secondary school classes. Four multi-day workshops were held at the NYHoS to train teachers to use the portable laboratory kits.

The primary goals of this evaluation are to assess: 1) the workshops' value for teaching the hands-on kit curriculum, 2) teachers' perception of the portable laboratories' value in the classroom, and 3) the relative knowledge gain of students who were and were not exposed to the portable labs.

A secondary goal of the evaluation is to determine if workshop participants who had taken part in Columbia University's Research Program for Science Teachers rated their skills and knowledge in relevant topics higher before and after the training than teachers who had not been part of the CU Research Program.

Methodology

Several methods were used in nine individual studies to assess teacher training and impact:

1. A baseline study measured participating teachers' incoming knowledge and skills in biotechnology and microscopy. The aggregated data could then be compared with similar self-reported skill and knowledge data after completing the workshops. Statistical analysis was used to compare CU and non-CU teachers' self-reported skills and knowledge.
2. Brief participant evaluations of each day of the multi-day training workshops helped NYHoS staff to assess the program's impact on the micro level.
3. Teachers' post-training evaluation measured the workshop's impact on knowledge and skills, comfort level with hands-on lessons and feelings of competence with the equipment. Statistical analysis compared CU and non-CU teachers' results.
4. Teachers' assessments of the classroom experience assessed the kits' usefulness to the curriculum, their mobility and flexibility, and if teachers would request to use them again.
5. "Final thoughts"—teachers' reflections on the program's impact on their students.

A summary of findings from each of the nine studies follows. The reader is advised to read on to Detailed Findings where significant variation between CU teachers and non-CU teacher performance is reported where found.

Summary of Findings: Biotech Kit Training

A total of 56 teachers participated in Biotech Kit training workshops, 19 of them had participated in the CU Summer Research Program and 37 had not.

Study 1. Baseline Survey

The vast majority of trainees (91%), taught in public schools; 17 taught in middle schools and 27 in high schools. Two were pre-service.

The majority taught regents courses in Living Environment (56.6%). One in three teachers (32.1%) taught no science regents courses. The most common reason students in regents courses do not take the regents examination is failure to fulfill laboratory time requirements.

The majority of participating teachers (79.2%) had Master's degrees. Teachers came into the course with varying degrees of skills and knowledge about relevant topics. Teachers who had participated in CU's Research Program for Science Teachers rated some of their skills and knowledge significantly higher than teachers who had not.

Study 2. Biotech Kit Training Daily Assessments

NYHoS educators used the results of participants' daily assessments to appraise their performance and modify the program as necessary. Overall, teachers deemed the material in each day's workshop useful for teaching. All participants were able to identify new skills and concepts they had learned.

Citing the investigations they planned to take into their classrooms, in addition to "all of them," participants noted: gel electrophoresis, making models of DNA using Molymods, Delicious DNA, micropipetting, restriction enzymes, Punnet squares and heredity, cancer genes and Bioterrorism.

All participants reported satisfaction with the NYHoS instructors.

Study 3. Teachers' Assessment of Biotech Kit Training Workshop

Teachers found the training "very useful" (84.6%), saying it "exceeded" their expectations.

Using the same scale as in the baseline study, teachers rated their skills and knowledge substantially higher after the training.

Teachers said the training provided great hands-on activities for use in the classroom. The vast majority of teachers said that the science content level in the workshops was "about right" (84.6%), and the instructors "always" explained the lab activities clearly (92.3%).

The most frequently mentioned suggestion to improve the training was to organize participants more efficiently, for example offering separate training sessions for experienced and inexperienced teachers, for middle school and high school teachers. CU teachers rated their knowledge of DNA structure and function significantly higher than did non-CU teachers; CU teachers rated their skill in micropipetting significantly higher than non-CU teachers did.

Teachers felt more competent and confident about using hands-on laboratory techniques in their classes after the training (there was no variation between CU and non-CU teachers' responses). Many teachers agreed (80.8%) that it would be helpful to have a NYHoS professional work with them the first time they used the kit in class.

Study 4. Assessment of Biotech Kit in the Classroom

By the close of the school year 2008, 28 workshop participants had used the Biotech kit in their classrooms, reaching some 2400 student. Teachers used the kit in Living Environment, Biology, Chemistry and General Science. They found the level of lessons to be "about right" overall. The vast majority of teachers (89.3%) said the kit was a "very useful" addition to the curriculum. Teachers reported that the kit conveys concepts of DNA structure and function, gel electrophoresis, practical applicability of biotechnology, genes and proteins, genetic testing, mutations, and lab techniques such as restriction enzymes and micropipetting.

The most frequent suggestion for improving the kit program was to extend the borrowing period from 1 week to 2 in order to complete more lessons. Most teachers (67.9%) would "definitely" request to use the Biotech Kit again. The kits appear to address the lack of opportunity students have to engage in hands-on science activities within the regular curriculum.

Summary of Findings: Microlab Kit Training

Study 5. Baseline Survey

The vast majority of the 46 participating teachers had a Masters degree. More than half (58.7%) taught in levels K-8th grade and the rest (41.3%) in high school. They said that the main reason high school students did not take the regents examination was failure to meet the laboratory time requirement.

Teachers were asked to rate their skills and knowledge in two areas—1) use of equipment and computer software, and 2) using organisms for purposes of microscopic investigation. While there was considerable variation in skill and knowledge levels, CU teachers rated their entering knowledge and skills significantly higher in several areas of equipment and programs than did non-CU teacher trainees.

Study 6. Microlab Training Daily Assessments

Daily assessments were useful for workshop instructors to plan their lessons. Participants varied widely in the depth and breadth of knowledge and experience. For example, one session consisted totally of CU Summer Research Program participants and another of teachers with limited laboratory experience. However, training sessions that combined experienced and inexperienced teachers were more difficult to plan and lead.

The daily assessments indicate that teachers were stimulated and engaged throughout the multi-day training, suggesting that instructors were able to adjust the sessions' content to the appropriate level so that the experienced teachers as well as the novices came away with new skills and knowledge. Virtually everything in the workshops was deemed useful for teaching. Teachers praised the session presenters' knowledge and presentation style.

Teachers said they would take most of the investigations into their classrooms. Investigations that stood out particularly were the Winogradsky column, the daphnia lab and "Yeasty Beasty."

Study 7. Teachers' Assessment of Microlab Kit Training Workshop

The great majority of participants (74.4%) found the training "very useful" for the courses they teach (63.6% of CU teachers and 78.1% of non-CU teachers). All participants' self-assessed skills and knowledge increased substantially after the training.

Virtually all teachers (95.3%) said the science content was "about right" and the instructors explained the lab activities and science concepts clearly. Overall, 2in 3 participants (67.4%) said they felt much more comfortable with hands-on lessons than before the training. CU teachers were less likely to see a major increase in their comfort level (54.5% and 71.9% respectively).

Three in four participants (74.4%) said it would be "very helpful" to have a professional from the NYHoS work with them and their classes the first time they borrow the kit. Fewer CU teachers than the others said it would be "very helpful" (54.5% and 81.3% respectively).

Findings indicate that the Biotech kit training increased teachers' knowledge in the pertinent content areas and concepts. The training increased teachers' comfort level with hands-on lessons in their classrooms, increasing their feelings of competence with laboratory techniques and equipment. Non-CU teachers showed more change in feelings of competence, presumably because they were less comfortable and confident in laboratory techniques before the training.

Study 8. Assessment of Microlab Kit In the Classroom

By the close of the school year 2008 (the end of the grant period), 14 of the training participants had used the Microlab kit in their classrooms, reaching some 1040 student. Teachers used the Microlab kit in 9 middle school and 10 high school classes (Living Environment/Biology, Chemistry, and General Science).

The Microlab lessons that were used by at least half the teachers were Basic light microscopy, What are magnification, resolution and field of view? What is life? Journey into microspace, and How do environmental changes affect the heart rate of Daphnia magna?

All the teachers found the kit a "useful addition to the curriculum." Some 2 in 3 (64.3%) found the kit "very useful," while 1 in 3 (35.7%) found it "somewhat useful" for conveying the following concepts: microorganisms' structure and function, microscopes and magnification, scientific method/lab techniques, effects of changes in the environment on living things, living/nonliving, value of technology in science. Just over half the teachers (8 in 14) said "yes, definitely," they would request the kit again and the rest said "yes, possibly."

Several teachers suggested that they would need to borrow the kit for more time in order for students to complete the longer-term investigations. Three in four teachers (78.6%) found the mobility and flexibility of the kit very helpful.

Teachers' responses reflect the lack of hands-on science experiences within the school science curriculum. The Microlab Kit addresses this issue however, many teachers found it challenging to take full advantage of the kit's resources during the time they had it.

Study 9. Final Thoughts

Close to the end of the school year teachers shared their "final thoughts" about the kits they had used in class. They noted the activities that were most engaging to students and those that were less successful, and provided anecdotes about their experience using the kits. Teachers were particularly impressed with how effective the hands-on activities were in engaging students who typically were not high achievers.

Conclusions and Implications

Teacher Training and Impact Utilizing Health Science Portable Laboratories succeeded in meeting its goals. Science teaching and learning were enhanced through the use of portable laboratories and hands-on modules for studying biotechnology and microscopy.

Teacher training proved highly effective in enabling teachers to use the hands-on curriculum, enhancing their perception of the value of portable laboratories in their classes. Overall, findings from nine separate studies indicate that the kits are a valuable resource for science teaching and learning, supplementing the lack of hands-on experiences available in the schools.

Teachers who had experienced the CU Summer Research Program for Science Teachers had significantly greater entering skills and knowledge in relevant biotechnology and microscopy topics than did non-CU teachers. Post-training skills and knowledge in both groups increased to similar levels for microscopy topics, but CU teachers were significantly more skilled at micropipetting and more knowledgeable about DNA structure and function.

Detailed Report

Introduction

The goal of a two-year SEPA grant, Phase II of a collaboration between Columbia University (CU) and the New York Hall of Science (NYHoS), was to enhance science teaching and learning through the use of portable laboratories and hands-on modules in middle and secondary school classes. Two types of kits were developed, one for studying biotechnology and another for microscopy. NYHoS education staff conducted teacher training workshops at the Hall to familiarize teachers with the use of laboratory equipment and hands-on lessons. After completing the training, the participants could schedule a week to borrow a kit. To ensure that teachers were comfortable using the equipment, a NYHoS educator was available on the first day that teachers used a kit in their classroom.

The primary goal of this evaluation is to assess the effectiveness of teacher training in curriculum programs enhanced by portable laboratories with hands-on modules, specifically,

1. the training's value for teaching the hands-on kit curriculum
2. teachers' perception of the portable laboratories' value in the classroom
3. the relative knowledge gain of students who were exposed to the portable labs and students who studied the same curriculum but without the additional modules.[1]

A secondary goal of the evaluation is to determine if teachers who had taken part in CU's Research Program for Science Teachers rated their skills and knowledge in relevant topics higher before and after the training than teachers who had not participated in the CU Program.

The teacher trainees were solicited from middle and high schools in the New York Metropolitan area, primarily the five boroughs.

This report aggregates nine studies conducted during 2007-'08: four studies pertain to the training for each kit (teachers' baseline knowledge of relevant topics, daily workshop assessments, teachers' final course evaluations and assessment of their experience using the kit in the classroom) and "Final Thoughts" consisting of teachers' anecdotes gleaned from using Kits in the classroom and their students' response to them.

[1] This last goal was abandoned when it became clear that it was unethical to assign a control group without the treatment. In addition, privacy regulations do not permit outsiders to test students in the public schools.

Methodology

The evaluator met with Columbia University and NYHoS participating staff to understand the program's goals and objectives in order to develop the evaluation design. Several methods were used to assess the training programs' effectiveness:

1. Baseline studies were conducted to measure all participating teachers' incoming skills and knowledge. Trainees were asked about their academic background, the courses and grade levels they teach and the number of students in their classes. They were provided a list of topics covered in the training and asked to assess their skill and knowledge with respect to each one. The data could then be compared with similar self-reported skill and knowledge levels after completing the workshops.
2. Participants completed a brief evaluation of each day of the multi-day workshops.
3. On the last day of the workshop, teachers completed a comprehensive evaluation in order to measure the training's effectiveness in increasing:
    - knowledge in the content areas and concepts;
    - comfort level with hands-on lessons on each topic;
    - feelings of competence with the biology equipment.
4. After the teachers used the portable laboratories in their classrooms in conjunction with curriculum units, they were asked to evaluate their experience. Specifically,
    - the kit materials' value to their curriculum needs;
    - the mobility and flexibility of the kit;
    - how well the lessons conformed to the relative inflexibility of school schedules;
    - whether the kit added enough value to their labs and lessons to be used beyond the initial period.
5. Finally, teachers were asked for their "final thoughts"—anecdotes reflecting the program's impact on their students.

Data were analyzed using the online resource SurveyMonkey and computer applications Excel and SPSS.

Biotech Kit Training

Four multi-day training workshops were conducted by NYHoS Education Department staff at the Hall on the following dates:

January 6, 7, 27 and 28, 2007
February 22-24, 2007
October 20, 27 and November 3, 2007
February 2, 3 and 9, 2008

Study 1. Biotech Kit Baseline Survey

An online survey was administered to incoming trainees to assess their entering skills and knowledge. A total of 56 teachers completed the baseline survey; 19 of them had participated in the CU Summer Research program and 37 had not. A summary of results follows.

The vast majority of trainees (91%) taught in public schools. Two taught in independent schools; the 3 who checked "other" were pre-service teachers (table 1).

Table 1. School Category

Answer Options	Response Percent	Response Count
Public	91.1%	51
Independent	3.6%	2
Parochial	0.0%	0
Other (please specify)	5.4%	3
	Answered question	56

Fewer middle than high school teachers participated in the program (17 and 27 respectively).

As Table 2 illustrates, 47 teachers taught non-regents science courses (see Appendix A for course lists).

Table 2. Non-Regents Courses by Grade Level

Answer Options	Response Percent	Response Count
Middle School	46.8%	22
High School	57.4%	27
	Answered question	47
	Skipped question	9

The majority of Biotech trainees taught regents courses in Living Environment (56.6%). One in three teachers (32.1%) taught no science regents courses (see table 3).

Table 3. Science Regents Courses Taught

Answer Options	Response Percent	Response Count
Living Environment	56.6%	30
Chemistry	11.3%	6
Earth Science	11.3%	6
Physics	1.9%	1
None	32.1%	17
	Answered question	53
	Skipped question	3

Table 4 illustrates the percentage of Biotech trainees' students who will take a regents examination during the current year.

Table 4. Percentage of Students Taking Regents Examination

Answer Options	Response Percent	Response Count
None	26.7%	12
1-25%	6.7%	3
26-50%	4.4%	2
51-75%	15.6%	7
76-99%	28.9%	13
ALL	17.8%	8
	Answered question	45
	Skipped question	11

The most common reason students will not take the regents examination is lack of adequate laboratory time (Middle school students do not have to take regents examinations). For example:

> *Did not complete 12 hours of lab seat time.*
>
> *Insufficient completed labs (Due to absences, and not making up) (Just 1 or 2 a year out of 100).*
>
> *I teach in NJ [where there are no regents].*

Teachers' Self-Assessed Skills and Knowledge

Teachers came into the course with varying degrees of skills and knowledge about relevant topics. Participants rated their skills and knowledge using a 5-point Likert-like scale (none=0, minimal=1, average=2, above average=3 and extremely knowledgeable=4). Teachers who participated in CU's Research Program for Science Teachers were more likely to rate their skills and knowledge in DNA structure and function, gel electrophoresis, micropipetting and restriction enzyemes significantly higher than those who had not.[2] Table 5 compares the average ratings of CU and non-CU teachers. (Tables 36-42 in Appendix C compare responses.)

Table 5. Average Ratings of Skills and Knowledge

Skills and Knowledge	CU Teachers	Non-CU Teachers
DNA Structure and Function	4.00	3.38
Punnet Square	3.79	3.32
Gel Electrophoresis	3.53	2.68
Centrifuging	3.79	3.00
Micropipetting	3.84	2.84
Restriction enzymes	3.37	2.54
Gene Transformation	3.16	2.46

[2] There was a significant difference between CU teachers' and non CU teachers' rating of their skill level in DNA structure and function $t(54)=2.188$, $p < .05$. The CU participants rated their skill level above average (M=4.00) and non CU participants rated it between average and above average (M=3.38).

There was a significant difference between CU teachers' and non CU teachers' rating of their skill level in Gel electrophoresis $t(54)=2.299$, $p < .05$. The CU participants rated their skill level between average and above average (M=3.53) and non-CU participants rated it between minimal and average (M=2.68).

There was a significant difference between CU teachers' and non CU teachers' rating of their skill level in Centrifuging $t(54)=2.310$, $p < .05$. The CU participants rated their skill level between average and above average (M=3.79) and non-CU participants rated it average (M=3.00).

There was a significant difference between CU teachers' and non CU teachers' rating of their skill level in Micropipetting $t(54)=2.794$, $p < .01$. The CU participants rated their skill level between average and above average (M=3.84) and non-CU participants rated it between minimal and average (M=2.84).

There was a significant difference between CU teachers' and non CU teachers' rating of their skill level in Restriction enzymes $t(54)=2.330$, $p < .05$. The CU participants rated their skill level between average and above average (M=3.37) and non-CU participants rated it between minimal and average (M=2.54).

Teachers' Background Data

Only 22 of the 56 teachers reported the number of years they had been teaching (table 6). Of those, the majority had taught from 4 to 6 years.

Table 6. Number of Years of teaching

Answer Options	Response Percent	Response Count
1-3 years	4.5%	1
4-6 years	54.5%	12
7-9 years	18.1%	4
10+	18.1%	4
	Answered question	22
	Skipped question	34

The vast majority of participating teachers (79.2%) had Master's degrees (table 7). Three of the participants were pre-service teachers.

Table 7. Highest Level of Education Completed

Answer Options	Response Percent	Response Count
Bachelor	15.1%	8
Masters	79.2%	42
Ph.D./Ed.D.	5.7%	3
	Answered question	53
	Skipped question	3

Of the 53 teachers who offered a reason for taking the workshop, half (52.8%) said their main reason was to improve their teaching, 1 in 4 (26.4%) said specifically they wanted to learn how to use the kits and slightly fewer than 1 in 4 teachers (22.6%) had personal reasons for participating, such as P-credits, salary increases or interest in science (table 8).

Table 8. Reasons for Taking Workshop

Answer Options	Response Percent	Response Count
Learn techniques, improve teaching	52.8%	28
Learn to use kits	26.4%	14
Personal reasons	22.6%	12
	Answered question	53
	Skipped question	3

The following quotes illustrate teachers' reasons for taking the Biotech workshop.

Learn techniques to improve teaching

To learn innovative and creative ways to enhance learning biotechnology for my students. Also to make their learning experience fun and meaningful.

I wanted to learn more about Biotechnology, and how I could make teaching it more palatable (sic) for my students. I have been working with students with diverse learning styles and I see that technology makes the lesson exciting and bridges the gap of learning if used properly.

I would like to incorporate the hands-on technique used in the labs in my Biology Class

Learn to use the Biotech kits

Opportunity for hands-on training, ability to rent equipment for use in the classroom.

To learn how to use the Biotech kits.

Great opportunity! Great lab materials. Jay Dubner made a great presentation.

Personal reasons

To enrich my knowledge of biology and further develop my research ability/skills.

It is something that I am interested in learning more about.

The vast majority of workshop participants (78.2%) had taken other professional development courses or workshops, listing 41 courses they had taken (see Appendix B).

Conclusions and Implications

Baseline data indicated that the workshop participants were comparable in number of years of teaching and level of formal education. However, teachers who had participated in the CU program rated some of their skills and knowledge of hands-on laboratory techniques significantly higher than the non-CU teachers.

Study 2. Biotech Kit Training Daily Assessments

After each day of workshop sessions participants answered the following four questions:

1. What is one new concept or skill you learned today?
2. Was there anything in today's workshop that was NOT useful to your teaching? Why?
3. Would you be interested in taking any of the investigations you learned today into your classroom? If so, which ones?
4. Additional Comments?

NYHoS educators used the responses to assess their performance and modify or improve the program as needed. All participants were able to cite new skills and concepts learned. Participants who taught in grades K-3 said that their students were too young to understand some of the lessons. Teachers cited the investigations they planned to take into their classrooms, specifying: "all of them", gel electrophoresis, making models of DNA using Molymods, Delicious DNA, micropipetting, restriction enzymes, Punnet squares and heredity, cancer genes and bioterrorism

Teachers' incoming knowledge and skills varied greatly: teachers who had participated in the CU Summer Research program were more experienced lab technicians while some of the non-CU teachers were relative novices. A few teachers who were more experienced in hands-on laboratory techniques expressed frustration about what they perceived as slowness in the workshop necessitated by less experienced participants.

Conclusions and Implications

Overall, the material in each days' workshops was deemed useful for teaching. All teachers reported satisfaction with the NYHoS instructors.

Study 3. Teachers' Assessment of the Biotech Training

Fifty-two (52 of 56) teachers completed a comprehensive questionnaire after the training, evaluating the workshop's effectiveness with regard to increasing

1. knowledge in the content areas and concepts;
2. comfort level with hands-on lessons on each topic;
3. feelings of competence with the equipment.

Table 9 reviews the four Biotech training groups, the dates on which they were held and the number of assessment responses.

Table 9. Final Assessment Response Rates

Groups	Number of Responses	Number of CU Responses
January 2007	14	12
February 2007	14	
October-November 2007	12	10
February 2008	12	5
Total	52	27

As table 10 indicates, the vast majority of teachers found the training "very useful" for their teaching (84.6%).

Table 10. Usefulness of Training

How useful was the Biotech Lab training	Percent	Count
Very useful	84.6%	44
Somewhat useful	13.5%	7
Not very useful	1.9%	1
Answered the question	100.0%	52

Table 11 indicates that the training exceeded the expectations of the vast majority of participants (84.6% answered "Better than I expected").

Table 11. Expectations

How closely did the training meet your expectations?	Percent	Count
Better than I expected	84.6%	44
About what I expected	15.4%	8
I was disappointed	0%	0
Answered the question	100.0%	52

Teachers' open-ended comments about how closely the training met their expectations were categorized and are illustrated in table 12 below.

Table 12. Expectations Explained

Comments About Training and Expectations	Percent	Count
Great hands-on activities	28.8%	15
I learned a lot	21.2%	11
Comments on the level or focus of instruction	19.2%	10
It was interesting, it was good (general)	7.7%	4
Saw connections to other subjects	3.8%	2
Other	3.8%	2
Answered the question		44
Skipped the question		8

Selected open comments follow (See Appendix D for full transcripts):

<u>Great hands-on activities</u>

I expected to come away with some activities that were well developed for my classroom and that I was test-running before I used them. This truly helped bring the biotech I used all summer in the lab simply into my classroom.

I was extremely happy that we were able to have hands-on activities. I expected to write lesson plans about genetics.

I expected lots of practicable activities and training on technology and that's what we got. The reason I say, "better than I expected" is the teaching activities. The gel electrophoresis and DNA made easy were fantastic and I'll use them.

I learned a lot

The training provided me with an in depth study of DNA that I am not familiar with. My science training was many years ago, even the tools we used were different. It was great that I was able to use more currently materials.

There was a lot of valuable information that has helped me as a student and a teacher. In addition, the genetic counselor brought in some great debatable information that can be used to stimulate scientific inquiry and promote collaboration amongst the students.

The trainer was very knowledgeable, which was awesome and isn't always the case. I learned and felt that we weren't treated like kids.

Comments on the level and focus of instruction: Pro

I knew that the kits would be useful if they were developed here, however I was continually impressed by the thoughtfulness behind the activities. While many of the approaches are similar to those I've employed, I think your level of preparation will elevate my teaching.

I thought that I would have to know more about the whole process in order to succeed but what I found was that even a teacher with very little background could succeed in this course—a physics teacher or an elementary science teacher.

The level of info was detailed and offered something for everyone at any level. I left feeling competent and able to perform the tasks. Also, [experiencing] the different types of learning was great. Brainstorming, posters, a visit from a counselor made it multidimensional and entertaining.

Most workshops I go to teach me very little I didn't know before. This is one of the few where I was challenged and incredibly excited to learn more. I've been telling everyone about how amazing this workshop has been.

Comments on the level and focus of instruction: Con

I thought that the skills would have been addressed more quickly—at times it was tedious to run 3 gels.

It was about what I expected. Some of the training wasn't as necessary since we had experience from Columbia.

Knowledge Gain

Workshop participants rated their skills and knowledge post-training using the same 5-point Liker-like scale that was used in the baseline study (none=0, minimal=1, average=2, above average=3 and extremely knowledgeable=4). Table 13 illustrates the average ratings for each skill or knowledge category for CU and non-CU teachers. CU teachers rated their knowledge of DNA structure and function and their skill with micropipetting significantly higher than did non-CU teachers.[3]

Where only 26.3% of CU teachers rated their knowledge of DNA structure and function as "extremely knowledgeable" before the training, twice as many (51.9%) rated it "extremely knowledgeable" afterwards. And while 21.6% of non-CU teachers rated their knowledge of DNA Structure and Function "none" to "minimal" before training, none rated it as such afterward (see tables 43-49 in Appendix C).

Table 13. Post-Training Skills and Knowledge

Skills and Knowledge	CU Teachers	Non-CU Teachers
DNA Structure and Function	4.52	4.17
Punnet Square	4.59	4.25
Gel Electrophoresis	4.44	4.12
Centrifuging	4.56	4.26
Micropipetting	4.63	4.29
Restriction enzymes	4.22	3.96
Gene Transformation	4.19	4.09

Figures 1 and 2 below compare CU and non-CU teachers' baseline and post-training mean ratings for skills and knowledge of relevant topics.

[3] There was a significant difference between CU teachers and non-CU teachers' post-training ratings of their skill level in DNA structure and function $t(49)=2.065$, $p < .05$. The CU teachers rated their skill level between above average and extremely knowledgeable (M=4.52) and non-CU teachers rated theirs between above average and extremely knowledgeable (M=4.17).

There was a significant difference between CU teachers and non-CU teachers post-training ratings of their skill level in micropipetting $t(49)=2.030$, $p < .05$. The CU teachers rated their skill level between above average and extremely knowledgeable (M=4.63) and non-CU teachers rated theirs between above average and extremely knowledgeable (M=4.29).

Figure 1

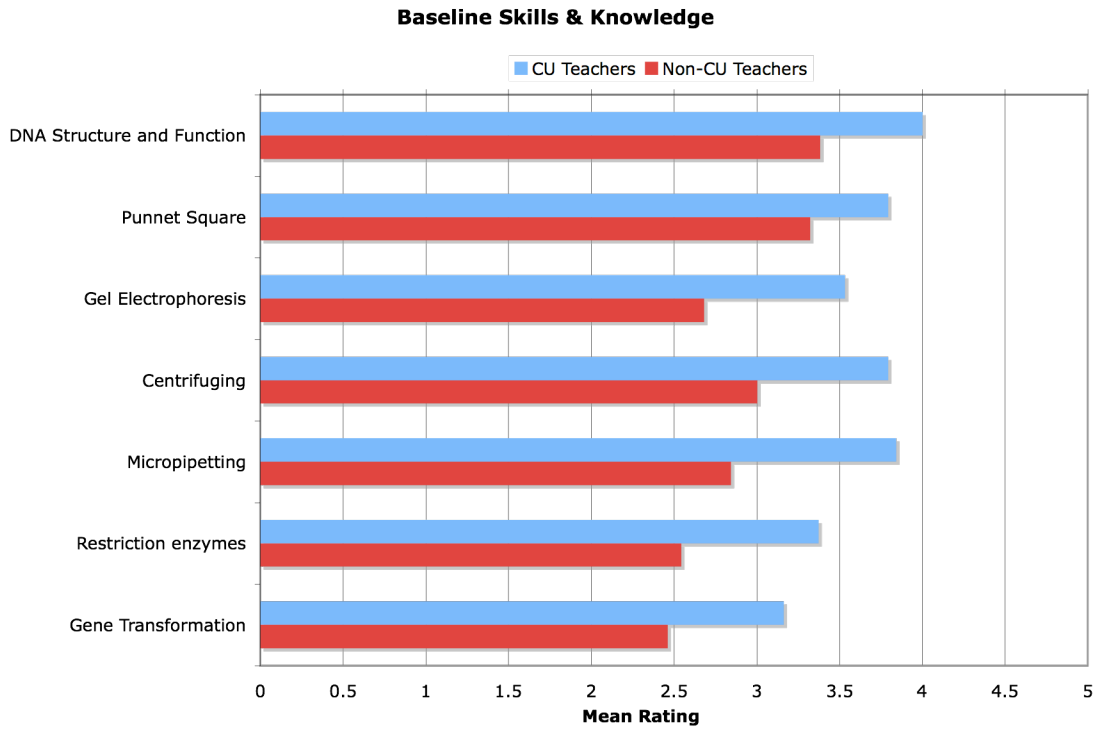
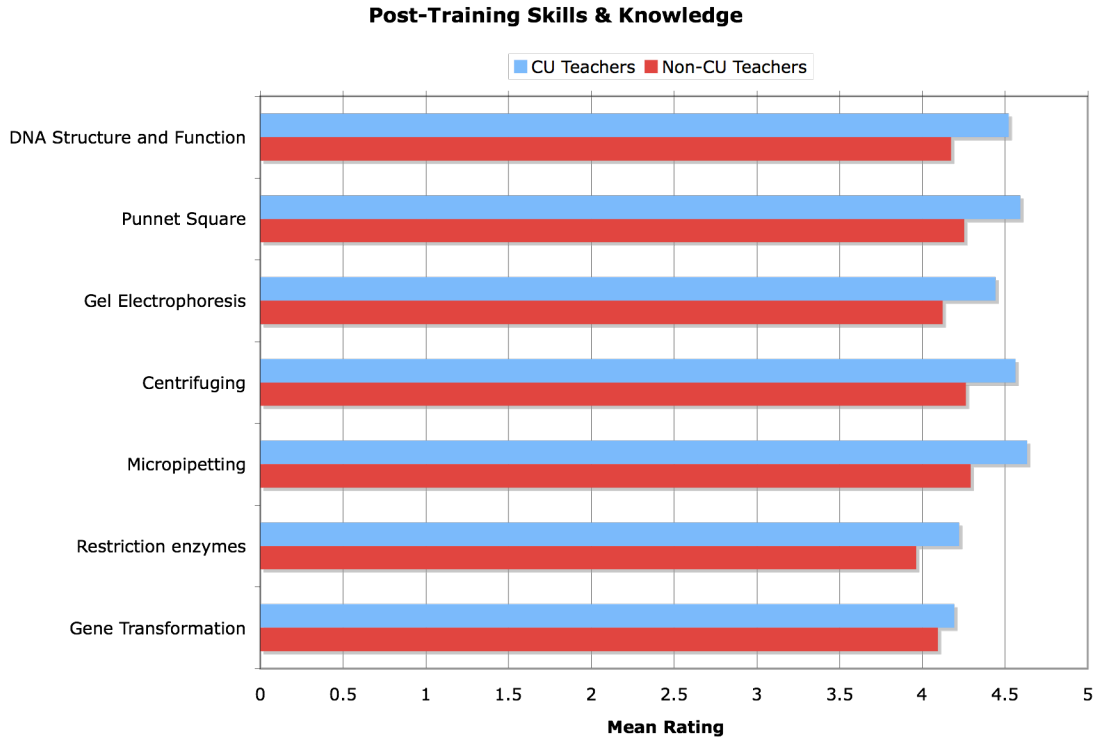


Figure 2



The vast majority of teachers (84.6%) said that the science content level in the workshops was "about right" (table 14). The few who differed reflect the extremes at both ends of the experience spectrum—three teachers found the level "too simple," two found it "too advanced" and three said the content was basically "about right" but added that some of it was "too advanced."

Table 14 Science Content

Science content was	Percent	Frequency
Too simple	5.8%	3
Too advanced	3.8%	2
About right	84.6%	44
Some OK, some too advanced	5.8%	3
Answered the question	100.0%	52

Selected comments in teachers' own words:

Although I studied the topic before, it was not fresh in my mind. This program actually motivated me to think about the topic and share it with my class.

I loved that it was so advanced—I just have to admit that having no background in this made it a little more difficult.

In general it was a review. On the first day I thought it would be too redundant, however, I found it helpful to hear and think of the questions my students may pose.

The vast majority of participants said the instructors always explained the activities and science content clearly (92.3%).

Table 15. Instructors

Did the instructors explain the lab activities and related science clearly?	Percent	Frequency
Yes, always	92.3	48
Not always	3.8	2
Yes, but…	1.9	1
Answered the question		51
Skipped the question		1

Table 16 lists improvements trainees suggested by category, followed by selected open-ended comments. The most frequently mentioned suggestion was to organize participants more efficiently so that teachers with lab experience could be together and move ahead at a faster pace, while novice teachers could take the time they needed to learn unfamiliar skills without

holding the others back. Teachers also suggested separate groups for middle and high school teachers, so that workshops could focus on grade appropriate pedagogy.

Table 16. Improvements

What can we do to improve the training?	Percent	Frequency
Comments on attendees (e.g., combining experienced and inexperienced students)	25.0	13
Comments on length of training and sessions	11.5	6
Comments on activities (e.g., need more equipment)	7.7	4
Bring in real scientists	1.9	1
No suggestions, everything good	13.5	7
Answered the question		31
Skipped the question		11

Suggestions for improving the training:

Miscellaneous

I think linking plasmids information could be presented a little more VISUALLY with the cuts.

Maybe give a small background packet with some of the basics that would be useful for teachers to know [in order] to understand all the activities well.

Supply all teachers with their own kits instead of a stipend.

Bring in a PCR. It would be great to extract and amplify our own DNA.

Group management

Perhaps it would be helpful to group teachers by grade level (middle vs. HS) to discuss pedagogy or what can be modified for younger students.

In the event that you have several participants who do not have biotech experience, you may want to suggest that they partner with more experienced participants earlier in the training (although the help of the staff was more than enough to keep us on schedule in this group).

Divide the training cohort into groups so one group does sickle cell activity one group cancer, one group bioterrorism

More time/days

Provide longer sessions with more practice. On occasion we did have to rush a bit to cover the scope of content covered. The tradeoff is between efficiency and saturation.

More…

More viewing boxes, so it doesn't bottleneck.

Bring more animation or visuals along with the lessons.

More practice rounds to shorten tasks. Successive approximations. More drilling of basic, redundant concepts. Not that we don't get it, but we should practice writing out "experimental sketches" to reinforce understanding.

Maybe include some websites for each of the difficult concepts so that students could be directed to these specific websites.

Everything good

It was very well organized and went smoothly. The classroom tips were helpful.

The training was excellent. I was hoping to take it as a 3-credit course. I enjoyed it anyway.

I thought there were ample opportunities to practice new skills learned during the training.

Comfort Level; Feeling Competent

After completing the training, how competent did teachers feel about using the equipment and what was their comfort level with hands-on lessons generally? Teachers described how they planned to use the Biotech kit as illustrated in table 17.

Table 17. Biotech Kit in your teaching

How will you use the Biotech Kit in your teaching?	Percent	Frequency
Work with students in class.	69.2	36
Supplement, enrichment	11.5	6
Work with other teachers	3.8	2
Non-specific activities	3.8	2
Answered the question		46
Skipped the question		6

In class

I wish I could keep the kits for a month to do all of the activities.

I would like to use it to enhance my forensic science classes and to help prepare my living environment students for the regents examination.

I plan to use it during our unit on life. Kids often bring up DNA because they hear about it but know nothing about DNA. After this workshop it will be great to go more deeply into it.

By the time we've reserved the kit, we will have covered chromosomal genetics, but not at the molecular level. The Molymod and DNA-made-easy will set up the unit, the electrophoresis will teach an application, and the transformation will spiral/extend it.

With Teachers

I plan to do at least 8 of the Labs over the 2-week period. I plan to invite one other teacher to share in my class labs by bringing her small class to join one of my small classes.

I will use it as a workshop week for the 8/9/10th grade researchers, AND work with a teacher of 3 LE classes. I'll team teach them in those classes (since my research schedule is not restrictive).

Enrichment/reinforcement

My plan for the glow genes activity is to run it as an after-school extension for interested students (and those in need of credit for a missed assignment).

To supplement the scope and sequence lessons that I teach.

I either plan to use it as an enrichment activity or to reinforce and introduce ideas and concepts. It will motivate students.

I am planning to have a number of students for an after school program along with the class period.

Teachers planned to borrow the kits starting 2 months after the first training session up through fall of 2008 (Table 18).

Table 18. When Teachers Plan to Borrow Kit

Plan to borrow Biotech Kit…	Percent	Frequency
Within the next 2 months	26.9	14
In 2-4 months	36.5	19
Next fall	11.5	6
Other	21.2	11
Answered the question		50
Skipped the question		2

The vast majority (80.8%) said it would be "very helpful to have a NYHoS instructor/kit developer work with them in class the first time they borrow the kit.

Table 19. How helpful will it be to have a professional developer work with you and your class the first time you borrow the kit?

Responses	Percent	Frequency
Very helpful	80.8%	42
Somewhat helpful	11.5%	6
Not very helpful	1.9%	1
Other	1.9%	1
Answered the question		52
Skipped the question		2

CU teachers' responses to this question were virtually identical to those of the rest of the teachers': the overwhelming majority believed that having a professional who had helped develop the kits work with them and their classes the first time would be very helpful. Three teachers added comments, for example:

It alleviates anxiety knowing someone with expertise and experience is there to guide you if you run into problems.

Anything Else We Should Know About The Training?

Teachers were asked for final comments so that any issues not covered in the questionnaire could be aired. While there were a few suggestions to improve the workshop, final comments consisted mainly of praise for the program and instructors:

Comments

You should think about developing a lab that would address antigens, antibodies, blood typing ABO and Rh factor.

The pedigree for the cancer lab would be very confusing for my students. I would have to create my own scenario because I teach a special education class.

I think providing PowerPoint presentations will be more helpful, most especially when discussing genetic disorders and the processes (steps flow chart).

I think more of the concepts are appropriate for high school students or advance middle school students. A training (DNA) for middle school must be separate.

Praise/Thanks (selected)

Thanks for your time and hard work

Tara is awesome.

Please find a way to keep offering it for free. Every teacher should get to use it.

Make it publicized to all schools and teachers.

Is there a training here that my students can join?

Frank, Tara, Preeti, are great with the course

Conclusions and Implications

Findings indicate that the Biotech kit training increased teachers' knowledge in the relevant content areas and skills. The training provided teachers with the comfort level to bring hands-on lessons into their classrooms, increasing their feelings of competence with laboratory techniques and equipment.

CU teachers had a head start and were already familiar with laboratory equipment and techniques before the training began. While all teachers skills and knowledge increased, CU teachers rated their skills and knowledge in some areas higher than teachers who had not participated in the CU Research program.

Study 4. Assessment of Biotech Kit Use in the Classroom

After using the portable laboratories in the classroom with the appropriate curriculum units, teachers evaluated their experience, specifically:

1. Were the kit materials a useful addition to their curriculum needs?
2. Was the mobility of the kit and its flexibility helpful?
3. Did the lessons conform to the relative inflexibility of their school schedules?
4. And finally, did the kit add enough value to their labs and lessons so that they would want to use it beyond the initial period?

By the close of the school year 2008, 28 workshop participants had used the Biotech kit in their public school classrooms, reaching some 2400 student. The teachers responded to an online survey about their experience.

Kit and Curriculum

Table 20 illustrates the courses in which teachers used the kits.

Table 20. Courses in which Biotech Kit was used

Answer Options	Middle School	High School	Response Count
Living Environment	1	15	16
AP Living Environment	0	0	0
Biology	0	6	6
AP Biology	0	3	3
Chemistry	0	2	2
AP Chemistry	0	0	0
General Science	3	4	7
Other	1	9	10
		Answered question	28

The Biotech kit can be used to teach 12 separate lessons. Teachers who used the kits were asked which lessons they taught and whether the level of each lesson was too advanced, too simple or about right. Table 21 summarizes their responses.

Table 21. Lesson used and level of difficulty rated

Answer Options	Too Advanced	Too Simple	About Right	Response Count
1. Introduction to DNA	0	0	17	21
2. DNA Structure & Function: Replication & Protein Synthesis	3	0	12	18
3. What is Biotechnology? Debates, Dilemmas & Decisions	0	0	11	20
4. Delicious DNA: Isolating DNA from Fruits	0	1	22	25
5. Preparing a Gel for DNA Study	0	0	18	24
6. Mastering the Art of Micropipetting	0	0	23	25
7. Principles & Practice of Agarose Gel Electrophoresis	2	0	22	26
8. Restriction Enzymes: The "Molecular Scissors" of Biotechnology	3	1	7	22
9. In Search of the Sickle Cell Gene	1	0	15	24
10 Cancer Gene Detection	2	0	8	23
11. Bioterrorism Threat in NYC Train Systems	1	0	10	21
12. Cloning Glow Germs! Transformation of E. Coli with Fluorescent Jellyfish Proteins	2	0	4	19

The level of most lessons was deemed “about right.” The most frequently used lessons were: gel electrophoresis, micropipetting, Delicious DNA, the sickle cell gene, preparing a gel for DNA study and cancer gene detection. All of the teachers said the kit was a useful addition to the curriculum: 25 teachers (89.3%) said, “Yes, very useful” and 3 teachers (10.7%) said, “Yes, somewhat useful.”

Teachers were asked to cite the top 5 specific concepts the kits conveyed to their students. Not all teachers cited 5 concepts.

The concepts are listed below in order of the frequency they were mentioned.

DNA structure and function

Gel electrophoresis

Applicability of Biotechnology

Genes & Proteins, Genetic testing, mutations

Restriction enzymes

Lab techniques

Micropipetting

Other

The category "Other" included topics that did not seem to fit in any other category:

Bacterial transformation

Macromolecular structures

Charges and currents

Use of marker and controls for comparison

Diploid number is different in different species

Growing colonies of bacteria

Solubility vs. Insoluble

Chemical reaction that buffers have on cell membrane

The importance of salt solutions for conductivity

Molecular model kits helped to visualize organic molecules

Suggestions to Improve Content

Restriction Enzyme Lesson

The Restriction Enzyme lesson does not seem to focus on the NYS Living Environment standards as closely as the other lessons. The questions posed in the lesson were confusing to my students and did not clarify the objective of explaining how the phosphate-sugar backbone of DNA is cut.

The Restriction Enzyme lab is important for students to understand how restriction enzymes are used to insert genes into or out of a genome. The lab does focus on resulting fragments that can be obtained from using certain restriction enzymes. I think it would help if there was a written sequence that was used to cut them. The Circular plasmids that are cut with scissors really help, because then translating this to what you see on the gels is hard to visualize without this. There should be enough circular plasmids so students can create the fragments for the certain restriction enzymes.

Miscellaneous

The only [lesson] I was able to use was the Delicious DNA. The students were able to follow the directions and understand the concept. They enjoyed it. I wished I could have scheduled in more activities but hopefully I will be able to borrow the kits in December when I introduce Genetics.

The only suggestion that I can think of is to include in the Cancer Gene Detection pedigree that Nancy is Valerie's sister.

[Add] a cloning experiment that does not include the use of live bacteria for 6th to 8th grade.

The legs on the Evotek electrophoresis boxes are weak. I broke the leg on one.

I thought that it was great - very user friendly and compact. The only thing is in the lab book there were some typos that I noticed.

Have the kit in Spanish. I did a lot of translation but since the Bilingual Education is increasing in Long Island it would be a plus.

All Good

I thought they were excellent!

The instructions were perfect because it gave the teacher an opportunity to make the correct amount for a group, or the entire class.

It's really well done.

Mobility and Flexibility

Teachers have set curriculum requirements they must complete within a relatively tight time frame. Was the Biotech kit flexible enough to meet their needs? Table 22 indicates that it was.

Table 22. Was the Mobility and Flexibility of Kit Helpful or Not?

Answer Options	Response Percent	Response Count
Yes, very helpful	92.9%	26
Yes, somewhat helpful	7.1%	2
No, not particularly helpful	0.0%	0
No, not at all helpful	0.0%	0
Other (please specify)	3.6%	1

The 1 "other" specified, "I like how you gave teachers flexibility to teach what they thought was applicable to their classes."

Teachers used ingenuity to cope with the relatively inflexible school schedule and curriculum requirements in order to use the experiments in the kit. They described how they prepared materials ahead of time (e.g., instead of letting students prepare their own gels) and tweaked the experiments so that they could provide the best value for their particular class. Teachers' comments suggest frustration at not being able to run all the lab activities in the span of the one-week they were allotted.

Selected responses in teachers' own words (full transcript in Appendix D):

I was able to borrow the kit during the exact time period that I was teaching DNA and biotechnology. The only issues that I had was that I could have used the kit for longer to teach more of the conceptual basis of DNA studies. I found that I rushed through

some of the content to get to the labs so that we could do them before we had to turn in the equipment. I would also have liked to do more of the activities if we had more time with the kit (DNA transformation).

Using the kit required a lot of preparation on my part. I had to prepare gels, run gels, and stain gels for students. In the end I learned that after students loaded gels to have them make their own gels for the next day. It was frustrating to students to run a gel on one day (I would have to continue running it after the class ended) and not see the gel for at least another day. I also had issues with the methylene blue stain not always staining gels. It was difficult to motivate students who did not see any results after pouring, running, and waiting for results. It was also difficult doing the activities with multiple classes because I do not have enough gel trays to pour that many gels. I pre-poured 24 gels per day for my living environment classes and made my forensics class make their own gels. Storing gels was an issue in this quantity.

Our school is fortunate to enjoy a flexible schedule, and so we're able to make up a curriculum that makes best use of all resources available. However, the alignment of the kit with basic state standard contents (especially DNA structure, function and electrophoresis) mean that simply using the kit as specified satisfies mandated objectives.

I found that preparing each experiment on my own time allowed me to execute each experiment in a timely manner. However, one week is not enough time to accomplish all the activities in the kit. We had a lot of fun and the students enjoyed each activity.

Scheduling Issues

The most frequent suggestion for improving the kit program had to do with time constraints.

Teachers suggested a 2-week instead of a 1-week rental period to use the kits in their classrooms.

Time Constraints

I felt that students were great at following directions (place regent X in tube Y) but they rarely stopped and thought about what they were doing. Also time restrictions made it difficult to discuss the theory behind procedures due to a rush to simply get the protocol completed in a short 45-minute class period (which by the time everyone is settled and then cleaning up is really only 30 minutes of working time). Much of the difficultly in using the kit was do to time constraints not flaws with the kit. I think if more time was given in class and with the kit we could have been more successful. To teach students about electrophoresis took most of the time. I felt rushed to move through the lessons without focusing on theory because I knew the materials with the kit had to be returned very quickly. Maybe if the kit was loaned in smaller sections for a week or so per section it would have worked better (transformation separate from electrophoresis). My students loved the transformation but by doing all activities it was difficult to discuss what was really happening during various reactions. I also felt the transformation kit was short on materials (agar) to pour plates. Students struggled with basic lab techniques (like sterile technique, pick cells off a Petri dish, and spreading cells). It would have been great to have some practice with these techniques before attempting a transformation.

This was a great kit. It's tough to do as much as one wants to in the rental period, but other than that, I have no complaints. PLUS with minimal school assets, it's possible to undertake some of the activities even after the rental is elapsed.

Because we rented as a 2-teacher team and were able to have the materials for 2 weeks, we were able to see how student familiarity and comfort with the equipment improved over that time. Even so, there were still many students who could have stood to have more time. It takes lots of practice to become proficient with these techniques, so either more time during this block would be recommended, or, perhaps "mini-rentals" where 1 or 2 pipettors could be taken out for a short period before the full labs are run.

Remind teachers that it does take TIME to do it- I was overzealous in what I tried to accomplish in the week.

Kit's Value

Did teachers perceive that the kits added enough value to their classes to request them again? Overall response was positive. As Table 23 suggests, 2 in 3 teachers would "definitely" request to use the Biotech Kit again and 1 in 3 said they would "possibly" request it again.

Table 23. Will Teachers Request Kit Again?

Answer Options	Response Percent	Response Count
Yes, definitely	67.9%	19
Possibly	32.1%	9
No I won't	0.0%	0
	Answered question	28

See Appendix E for participants' unsolicited comments to the workshop leader.

Conclusions and Implications

Participants' comments indicate that the kit was a valuable asset to science teaching and learning: the kits address the lack of opportunity students have to engage in hands-on science activities within the regular curriculum. Teachers approved of the kits' mobility and deemed them flexible enough for their often-rigid schedules. Many teachers commented that they would have liked to have more time to use the kits with their students: in one week they could not conduct as many of the lessons as they would have liked.

Microlab Kit Training

Four multi-day training workshops were conducted by the NYHoS Education Department staff in a Hall classroom. The dates were as follows:

April 2-5, 2007 (p-credit 4/6, 4/7)
August 6-9, 2007 (p-credit 8/10, 8/11)
November 17, 18 & December 8, 2007
April 22-24, 2008

Study 5. Microlab Baseline Survey

Teachers completed a baseline survey online similar to the one used for Biotech trainees. There were 46 participants from various public schools and 1 pre-service teacher. Eleven of the trainees had participated in the CU Research program. The majority of participants taught in levels below high school (table 24).

Table 24. Grade Level Taught

Answer Options	Response Percent	Response Count
Pre-K Elementary	15.2%	7
Middle School	43.5%	20
High School	41.3%	19
Answered question		45
Skipped question		2

All but one high school teacher taught non-regents courses (middle school does not participate in the regents examinations; see appendix A for list of non-regents courses). Table 25 details the science regents courses taught by participants and table 26 summarizes the number of students in those classes who will take the regents examination.

Table 25. Science Regents Courses Taught

Answer Options	Response Percent	Response Count
Chemistry	9.5%	4
Earth Science	14.3%	6
Living Environment/Biology	38.1%	16
Physics	0.0%	0
None	38.1%	16
Answered question		42
Skipped question		4

Table 26. Number of students in Regents classes who will take the examination this year

Answer Options	Response Percent	Response Count
None	35.0%	11
1-25%	5.0%	1
26-50%	0.0%	1
51-75%	10.0%	4
76-99%	35.0%	10
ALL	15.0%	5
	Answered question	32
	Skipped question	14

The main reason students do not take the examination is meeting the laboratory time requirement, e.g., "Poor lab attendance, incomplete or missing labs. Students MUST complete 1200 minutes of lab seat time."

Other reasons for not taking the regents examinations were:

My 8th Grade students take the 8th Grade Science Test. The other students are not tested because they are 5th, 6th, or 7th graders. I do not teach any regents classes.

Our school operates a 2-year LE Curriculum, mixing 9th and 10th grade students, with only second year kids sitting as lab eligible.

They are seniors and have already passed a regents exam.

Regents are not offered at my school.

The principal selected one class as the pilot class. Hopefully next year all of the science class will take the regents.

They are not going to be prepared.

Teachers' Self-Assessed Skills and Knowledge

Participants were asked to rate their skills and knowledge using a 5-point Likert-like scale (none=0, minimal=1, average=2, above average=3 and extremely knowledgeable=4). Teachers rated their skills and knowledge in two areas: first in the use of equipment and computer software, second in using organisms for purposes of microscopic investigation. Tables 27 and 28 compare the mean ratings of CU and non-CU teachers (see Tables 50-60 in Appendix C for detailed comparison tables).

Most trainees rated their skills and knowledge of equipment and software on the low side, CU teachers rated their skill and knowledge in four areas significantly higher than non-CU teachers.[4]

Table 27. Mean Ratings of Skills and Knowledge Using Equipment and Programs

Skills and Knowledge	CU Teachers	Non-CU Teachers
Microscope	3.90	3.66
Deep-well slides	3.00	3.00
Videomicroscope	2.80	1.71
Video camera	3.10	2.71
Projector	3.50	3.11
MacClade software	1.20	1.03
PAUP (Phylogenic Analysis Using Parsimony) software	1.40	1.00
Vernier Probeware (Logger Pro, Lab Pro Unit, CO_2 Sensors)	2.20	1.51
Clear One Flex Cam	2.10	1.34
iMovie	1.90	1.43
iPhoto	2.00	1.54

Table 28. Skills and Knowledge Using Organisms

Skills and Knowledge	CU Teachers	Non-CU Teachers
Live microorganism cultures	3.40	2.91
Yeast CO_2 production	3.10	2.40
Chaos Chaos amoeba	1.90	1.69
Daphnia magna	2.40	1.77
Plating bacteria with antibiotics	3.40	2.29

Figures 3 and 4 compare CU and non-CU teachers' self-assessed ratings.

[4] There was a significant difference between CU participants' and non-CU participants' pre-training ratings of their skill level in video microscopy $t(43)=3.276$, $p<.05$. The CU participants rated their skill level between minimal and average (M=2.80) and non-CU participants rated theirs between none and minimal (M=1.71).

There was a significant difference between CU participants' and non-CU participants' pre-training ratings of their skill level in Phylogenic Analysis Using Parsimony $t(43)=2.077$, $p<.05$. The CU participants rated their skill level between none and minimal (M=1.40) and non-CU participants rated theirs none (M=1.00).

There was a significant difference between CU participants' and non-CU participants' pre-training ratings of their skill level in Vernier Probeware $t(43)=2.140$, $p<.05$. The CU participants rated their skill level between minimal and average (M=2.20) and non-CU participants rated theirs between none and minimal (M=1.51).

There was a significant difference between CU participants' and non-CU participants' pre-training ratings of their skill level in Clear One Flex Cam $t(43)=2.496$, $p<.05$. The CU participants rated their skill level between minimal and average (M=2.10) and non-CU participants rated theirs between none and minimal (M=1.34).

Figure 3.

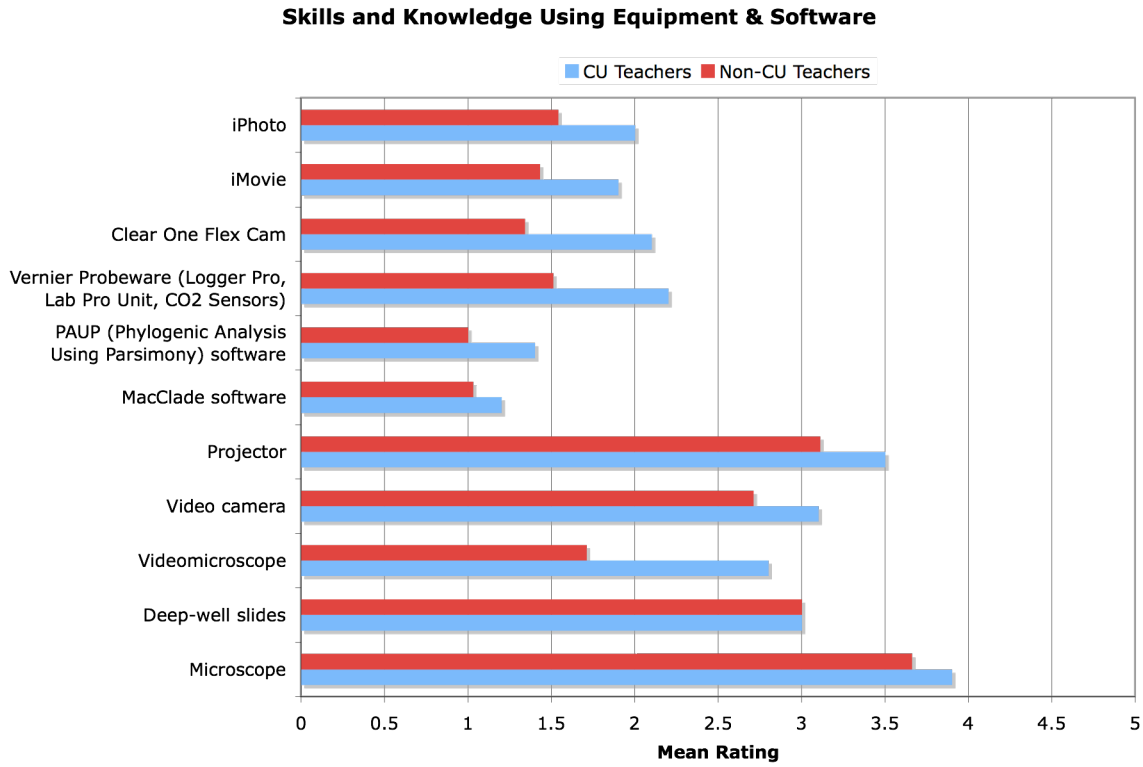
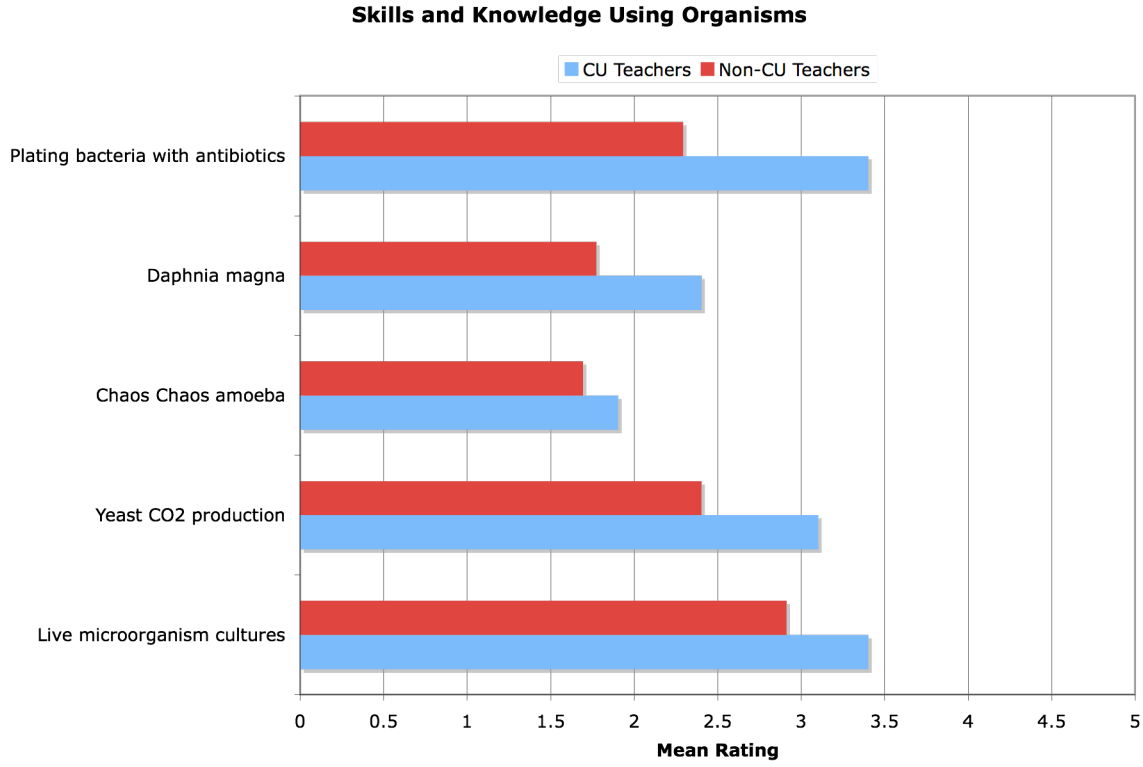


Figure 4.



Teachers' Background Data

The vast majority of teachers had a Masters degree (table 29). Most of the workshop participants were experienced teachers: the largest percentage (37.8%) had been teaching between 4 and 6 years, and many (28.9%) had been teaching for 10 or more years (table 30).

Table 29. Highest Level of Education Completed

Answer Options	Response Percent	Response Count
Bachelor	4.8%	1
Masters	85.7%	41
Ph.D./Ed.D.	9.5%	3
	Answered question	45
	Skipped question	1

Table 30. Years of Teaching Experience

Answer Options	Response Percent	Response Count
1-3 years	15.6%	7
4-6 years	37.8%	17
7-9 years	17.8%	8
10+	28.9%	13
	Answered question	45
	Skipped question	1

Most of the participants (82.2%) had taken other professional development courses during the past 5 years. (See Appendix B for list of courses.) Half the teachers said they took the Microlab workshop to learn techniques to improve their teaching, 1 in 5 teachers wanted to learn to use the kits and 1 in 3 had personal reasons (see table 31).

Table 31. Teachers' Main Reason for Taking the Microlab Training

Answer Options	Response Percent	Response Count
Learn techniques, improve teaching	50.0%	22
Learn to use kits	20.5%	9
Personal reasons	29.5%	13
	Answered question	44
	Skipped question	2

In teachers' own words (selected responses):

Learn techniques to improve teaching

I hope to find more lessons that will be hands-on and motivate my students to want to learn more science.

To enhance my knowledge in life science. Middle school curriculum is a spiral curriculum. I need to teach life science, Earth science and physical science. My background is mostly on physical science. I need more trainings in life science and earth science so that I can enrich my students in terms of concept.

Learn to use the Microlab kits

There are some newer equipment that are being used in the Microlab activities and I want to be exposed to these equipment and the companies that make these equipment.

To get new ways to teach genetics. To use lab equipment that I otherwise don't have access to.

Personal reasons

For salary differential, and an exposure to useful scientific technology.

Conclusions and Implications

Fewer than half the teachers taught in high school. The majority had little experience with laboratory equipment, technology or using organisms. Only ten of the 47 trainees were CU research program participants. The main reason teachers said they took the training was to improve their teaching.

Study 6. Microlab Training Daily Assessments

Participants assessed each day of the training sessions by answering the following questions:

1. What is one new concept or skill you learned today?
2. Was there anything in today's workshop that was NOT useful to your teaching? If so, why?
3. Would you be interested in taking any of the investigations you learned today in to your classroom? If so, which ones?
4. Additional Comments?

The assessments were useful for workshop instructors to plan or adjust their lessons. Workshop participants varied widely in the depth and breadth of knowledge and experience about the subjects.

The daily assessments indicate that teachers were stimulated and engaged throughout the multi-day training, suggesting that instructors were able to tailor the sessions' content to the class level, so that experienced participants as well as novices came away with new skills. Teachers' comments were quite specific when referring to new concepts and skills learned, as well as investigations they planned to use in the classroom. Virtually everything in the workshops was deemed useful for teaching. A few of the participants teaching K-3 said their students were too young to understand many of the lessons.

Teachers were able to secure p-credits by taking the workshop. Some of them would not be using many of the lessons in their classrooms—certainly not the pre-k teacher. However, they said that the knowledge they gained was useful overall to their careers and personal development as educators.

Conclusions and Implications

Although teachers planning to use the lab experiments in their classes were pleased to have the kits compensate for their schools' lack of lab equipment for hands-on use, informal conversation revealed concerns: 1) Equipment: the kits' contents might be insufficient for the number of students in their classes, and 2) Time constraints: due to the limited amount of time allotted for lab work in the curriculum, teachers might not be able to utilize all the lessons.

Teachers said they would use most of the investigations they learned in the workshop into their classrooms. Investigations that stood out particularly were the Winogradsky column, the daphnia lab and the "Yeasty Beasty."

Teachers noted that the workshops' timing was not always synchronous with the school curriculum: for example, the unit that would have been the best fit for using the kit might be finished by the time the teacher was able to borrow it. Teachers wondered whether the training would be fresh enough in their minds the following year when the unit was repeated.

Teachers praised the session presenters' knowledge and presentation style.

Study 7. Teachers' Assessment of the Microlab Training

Forty-three teachers completed a comprehensive questionnaire after the training, evaluating the workshop's effectiveness with regard to increasing

1. knowledge in the content areas and concepts;
2. comfort level with hands-on lessons on each topic;
3. feelings of competence with the equipment.

Table 32 reviews the four Microlab training workshops and specifies the dates on which they took place and the number of participants in each.

Table 32. Workshop Sessions

Group	Number	CU Teachers
April 2-5, 2007	15	1
August 6-9, 2007	9	
November 17, 18 & December 8, 2007	12	10
April 22-24, 2008	7	
Total	43	11

Knowledge Gain

Only 1 teacher (not a CU teacher) found the training "not very useful;" 63.6% of CU teachers and 78.1% of the non-CU teachers said the training was "very useful." The remaining trainees said it was "somewhat useful."

Table 33. How useful was the Microlab training for the course(s) you teach?

How Useful	Percent	Count
Very useful	74.4%	32
Somewhat useful	23.3%	10
Not very useful	2.3%	1
Answered the question	100.0%	43

Workshop participants rated their skills and knowledge using the same scale as they had in the baseline study using a 5-point Likert-like scale (none=0, minimal=1, average=2, above average=3 and extremely knowledgeable=4). Tables 34 and 35 compare the mean ratings of CU and non-CU teachers.

Al trainees' self-assessed skills and knowledge increased substantially after the training (there was no statistically significant variation between CU and non-CU teachers; tables 66-76 in Appendix C compare CU and other teachers' post-training skills and knowledge).

Table 34. Skills and Knowledge Using Equipment and Software

Skills and Knowledge	CU Teachers	Non-CU Teachers
Microscope	4.10	4.44
Deep-well slides	4.70	4.25
Videomicroscope	4.00	4.00
Video camera	4.00	4.13
Projector	4.50	4.13
Vernier Probeware (Logger Pro, Lab Pro Unit, CO_2 Sensors)	3.80	3.97
Clear One Flex Cam	4.30	4.17
iMovie	3.80	3.84
iPhoto	3.90	3.70

Table 35. Skills and Knowledge Using Organisms

Skills and Knowledge	CU Teachers	Non-CU Teachers
Live microorganism cultures	3.90	3.93
Yeast CO_2 production	4.10	4.13
Chaos Chaos amoeba	3.50	3.88
Daphnia magna	4.00	3.97
Plating bacteria with antibiotics	3.80	4.25

Figures 5 and 6 below compare CU and non-CU teachers' baseline and post-training mean ratings for skills and knowledge using equipment and software (McClade and PAUP software were ultimately excluded from the training). Figures 7 and 8 compare CU and non-CU teachers' baseline and post-training mean ratings for skills and knowledge using organisms.

Figure 5

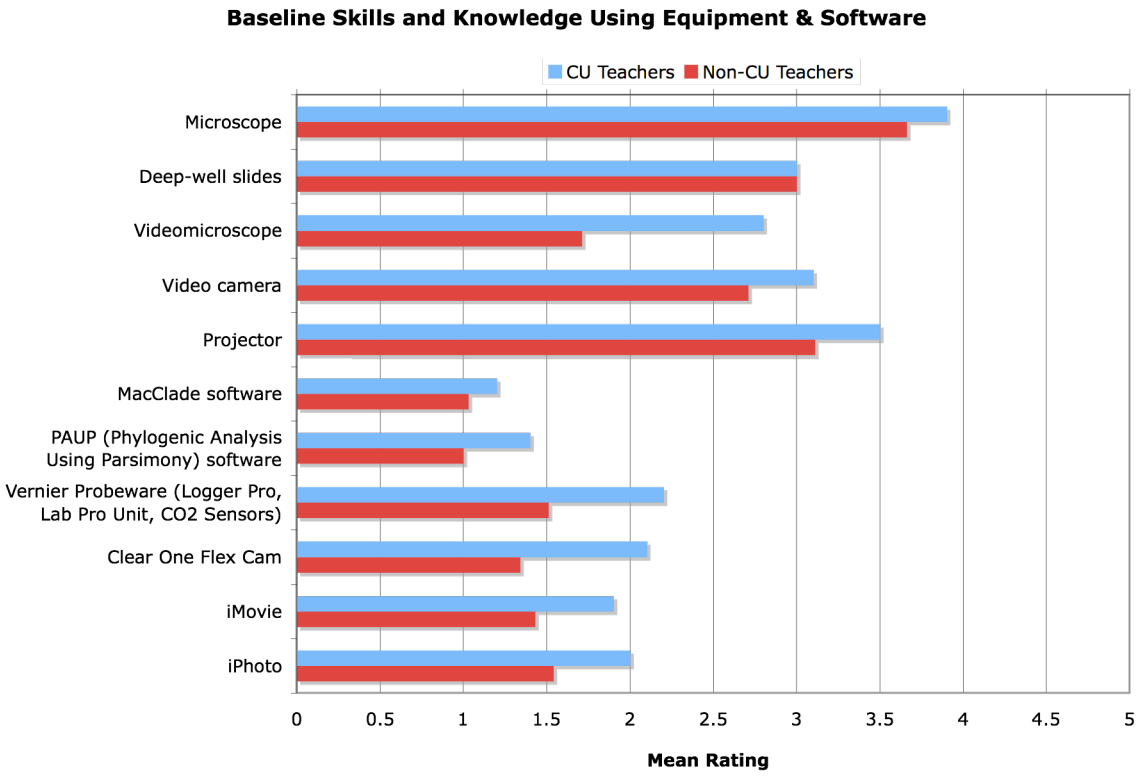


Figure 6

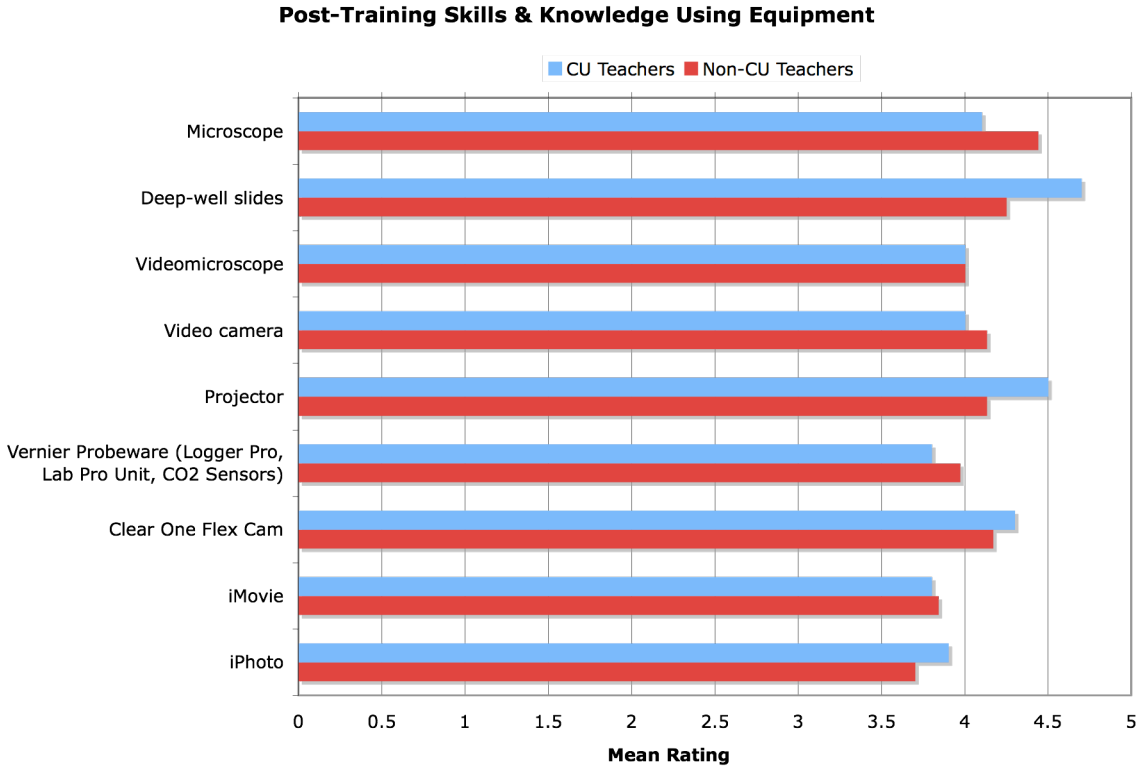


Figure 7

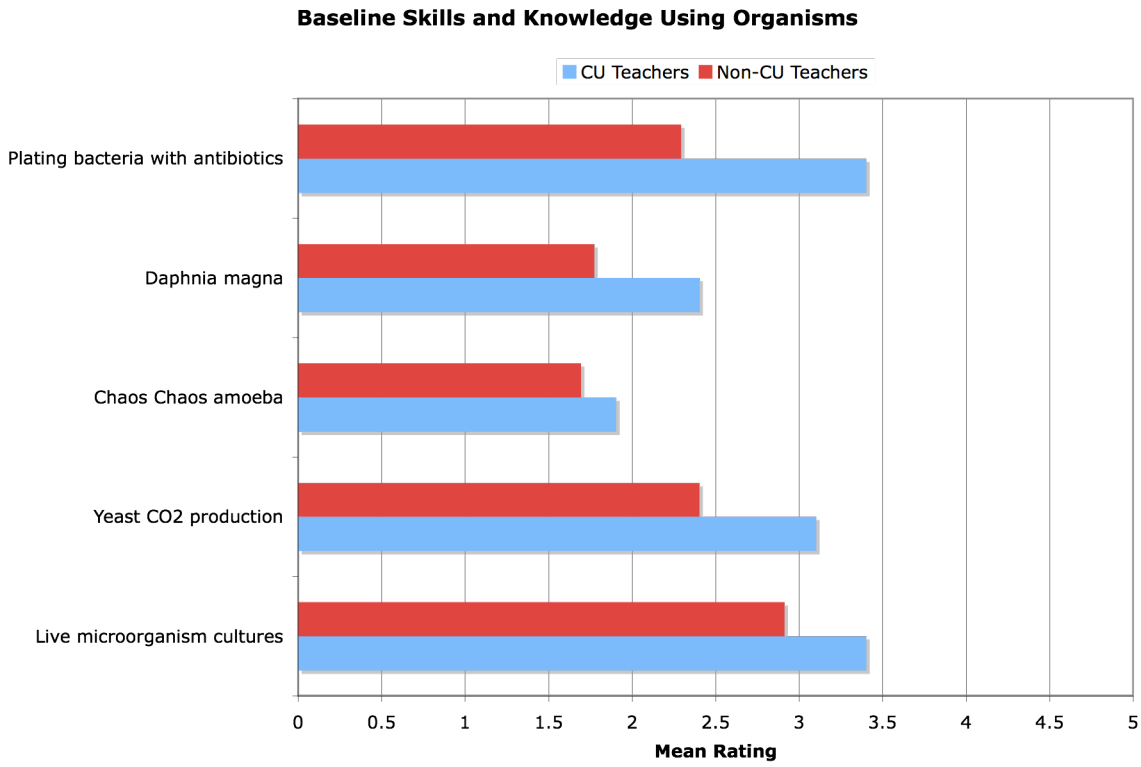
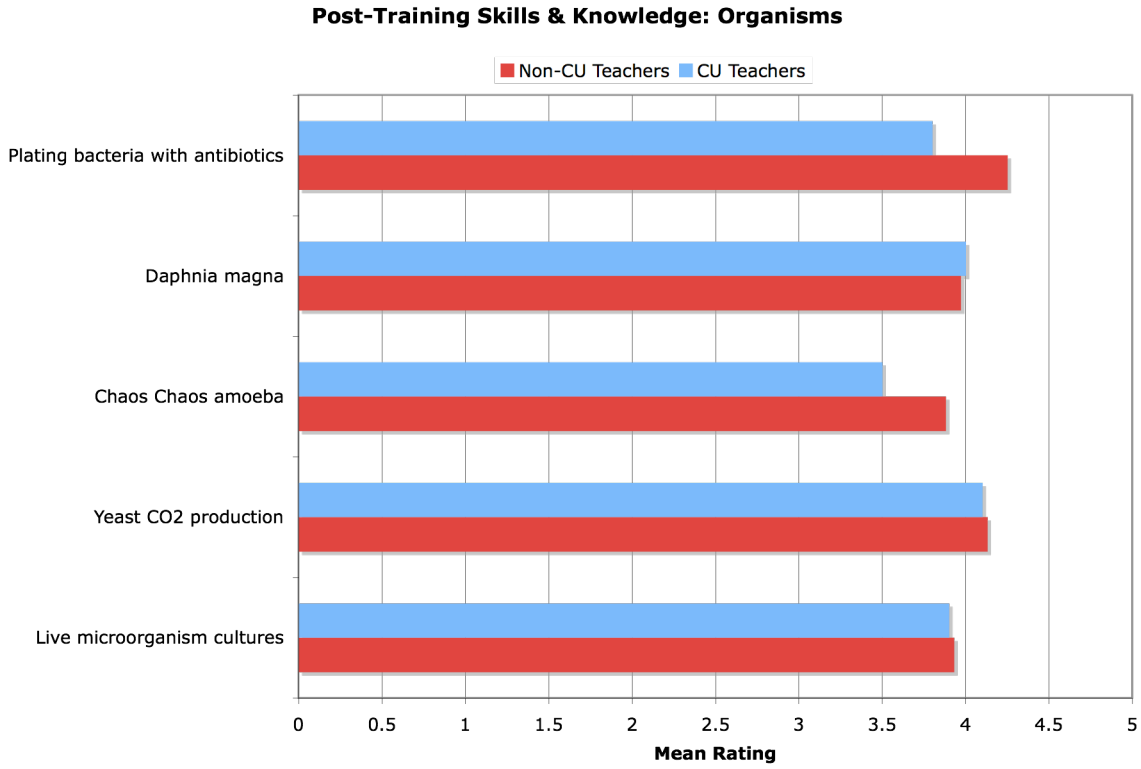


Figure 8



Virtually all workshop participants (95.3%) said the science content was "about right" and the instructors explained the lab activities and science concepts clearly (tables 36 and 37).

Tale 36. Science Level

Science level was…	Percent	Count
Too advanced	0.0%	0
Too simple	4.7%	2*
About right	95.3%	41
Answered the question	100.0%	43

*1 CU and 1 non-CU teacher

Table 37. Did the instructors explain the lab activities and related science clearly?

Instructors Explained..	Percent	Count
Yes, always	95.3%	41
Answered the question		41
Skipped the question		2

Comfort and Competence Using Hands-on Lessons

The majority of teachers felt "much more comfortable with hands-on lessons" after taking the workshop (54.5% of CU teachers and 71.9% of non-CU teachers); most of the remaining teachers felt "a little more comfortable with hands-on lessons (36.4% of CU teachers and 25% of non-CU teachers). One CU and 1 non-CU teacher said they felt "about the same as before the training" about hands-in lessons: was this because they were comfortable with hands-on lessons before the training, or were they still *un*comfortable with them? None of the trainees felt "less comfortable."

Table 38. Do you feel more or less comfortable with hands-on lessons than before the training?

Comfort Level	Percent	Count
Much more comfortable with hands-on lessons	67.4%	29
A little more comfortable with hands-on lessons	27.9%	12
I feel about the same as before the training	4.7%	2
Answered the question		43

Most of the participants planned to borrow the kit within 2 to 4 months after the training. The last workshop took place in April 2008, too close to end of year exams for teachers to borrow

the kits during that school year. Teachers' estimations of when they planned to borrow the Microlab kit were:

Table 39. Plan to Borrow Kit

Plan to borrow kit	Percent	Count
Within the next 2 months	16.3%	7
In 2-4 months	46.5%	20
Next fall	25.6%	11
Other	11.6%	5
Total	100.0%	43

All teachers increased their comfort level with using portable lab equipment in their classes.

Table 40. Comfort Level Using Hands-on Lessons

How comfortable	Percent	Count
Very comfortable	62.8%	27
Somewhat comfortable	37.2%	16
	Answered the question	43

There was no perceptible difference between CU and non-CU teachers' comfort levels.

Did teachers think it would be helpful to have a professional developer from the NY Hall of Science work with them and their classes the first time they borrow the kit? Three in four (74.4%) said it would be "very helpful" and the rest said "somewhat helpful." Fewer CU teachers than non-CU teachers said it would be "very helpful" (54.5% and 81.3% respectively).

Conclusions and Implications

Findings indicate that the Biotech kit training increased teachers' knowledge in the relevant content and conceptual areas and skill in using the equipment. The training provided teachers with the comfort level to bring hands-on lessons into their classrooms, increasing their feelings of competence with laboratory techniques and equipment. There was no statistically significant difference in the self-reported skills and knowledge of CU and non-CU teachers.

Study 8. Assessment Of Microlab Kit Use In Classroom

After using the portable laboratories in the classroom with the appropriate curriculum units, teachers evaluated their experience, specifically,

1. Were the kit materials a useful addition to their curriculum needs?
2. Was the mobility of the kit and its flexibility helpful?
3. Did the lessons conform to the relative inflexibility of their school schedules?
4. And finally, did the kit add enough value to their labs and lessons so that they would want to use it beyond the initial period?

By the close of the school year 2008 (the end of the grant period), 14 of the workshop participants had used the Microlab kit in their public school classrooms, reaching some 1040 student. The Microlab kit was used in 9 middle school and 10 high school classes. One teacher used the kit in K-2 classes and another in 3-5 classrooms.

The teachers responded to an online survey about their experience.

Kits and Curriculum

Teachers listed the courses in which they used the kits (table 41).

Table 41. Courses in which Microlab Kit Was Used

Answer Options	Middle School	High School	Response Count
Living Environment	2	4	5
AP Living Environment	0	0	0
Biology	1	1	2
AP Biology	0	1	1
Chemistry	0	1	1
AP Chemistry	0	0	0
General Science	6	1	6
Other	0	2	2
		Answered question	12
		Skipped question	2

Table 42 illustrates the number of teachers who used each Microlab lesson along with teachers' ratings of each lesson's level of difficulty. The N/A column is the number of teachers who said they did not use the lesson.

Table 42. Lessons Using Microlab Kit and their Level of Difficulty

Answer Options	Too Advanced	Too Simple	About Right	N/A	Response Count
1. Basic light microscopy	0	0	8	6	14
2. What are magnification, resolution and field of view?	1	0	6	7	14
3. What is life?	0	0	7	7	14
4. Journey into microspace	0	1	7	6	14
5. Cell in a bag	0	0	3	11	14
6. How do we make sense of and organize the living world?	0	0	3	11	14
7. What are the best conditions for the land of DLOM to flourish?	0	0	4	10	14
8. How do environmental changes affect the metabolism of yeast and influence CO2 production?	0	0	6	8	14
9. How do induced environmental changes affect bacteria?	0	0	1	13	14
10 What are the effects of hypertonic, hypotonic and isotonic solutions on Chaos chaos?	1	0	1	12	14
11. How do environmental changes affect the heart rate of Daphnia magna?	1	0	6	7	14
12. How are aquatic microscopic invertebrates related to one another?	0	0	4	10	14
				Answered question	14
				Skipped question	0

The lessons that were used by at least half the teachers were Basic light microscopy, What are magnification, resolution and field of view?, What is life?, Journey into microspace, and How do environmental changes affect the heart rate of Daphnia magna?

All the teachers found the kit a "useful addition to the curriculum." Some 2 in 3 (64.3%) found it "very useful," while 1 in 3 (35.7%) found it "somewhat useful."

Teachers were asked to list up to 5 specific concepts the Microlab kit conveys to students. The concepts were categorized as follows, in order of frequency:

Microorganisms, structure and function
Microscopes and magnification
Scientific method/lab techniques
Effects of changes in the environment on living things
Living/nonliving
Value of technology in science

Suggestions to Improve Kit

From their experience, eight teachers offered suggestions to improve the kit. Two suggestions were to allow more time to use the kit in order to permit students to complete the longer-term investigations.

Time constraints

Time is always the limiting factor. I was definitely unable to use as much of the kit as I would have liked, and I had it for a full 2 weeks! Activities just never move as quickly as we would hope. However, once the kids had a relatively good handle on the methods, they were able to come in and begin their work almost immediately. We just ran into some roadblocks with Daphnia dying.

Having done both the micro and biotech kits, the micro is TOTALLY different than biotech. The investigations are more long-term and open-ended. That said, I wish we could have longer rental periods in order to accommodate the longer-term investigations.

It's challenging to do all of the lab work, even a scaled-back version, in such a short time. Teachers may want to pre-teach some of the kit before they actually receive the materials, do fewer labs, or run double periods when they have the kits to fit it all in. The materials are all great, it's the time that's short.

The lab should not have taken as long as it did, but because my classes are only 40 minutes, we had to break it into 3 sessions: a "practice run," where we set up the experiment and got about 3 minutes into the loggerpro graph, a day 2 where we started over with new

yeast, new sugar, etc and ran the full 10 minutes of loggerpro, and a day 3 where we talked about the results.

Other

[Include] suggestions on how to make the lessons simple for 6th and low function classes. For example I used the balloons for my low function class and I simplified the equation to calculate CO_2 production.

I had an older version of the instructions. I could have used one that was current.

I love this kit! My students did have some trouble getting good videos of the daphnia. But I think with more practice they would have finally gotten a hang of it. About half of the students did a great job, so we just used their videos.

The weight and amount of equipment was the most burdensome part of moving the kit to and from the NY Hall of Science.

Mobility and Flexibility

The vast majority of teachers (78.6%) found the mobility and flexibility of the kit "very helpful" (see table 43).

Table 43. Mobility and Flexibility of Kit Helpful or Not

Answer Options	Response Percent	Response Count
Yes, very helpful	78.6%	11
Yes, somewhat helpful	7.1%	1
No, not particularly helpful	7.1%	1
No, not at all helpful	0.0%	0
Other (please specify)	7.1%	1
	Answered question	14

One of the teachers added:

YES VERY HELPFUL, AND, something else about the Microlab borrowing I don't know where else to write: having Tara from the Hall of Science come to the school was a fantastic asset. She not only helped me during the lesson, she also spent time with my administrators, explaining to them what each part of the equipment did, discussing with them their educational value. My administrators, now that they have been exposed to the equipment along with such a clear explanation, are very encouraged to buy some of the Microlab equipment for our school. Thank you!!!!!!!!!!

Teachers described how they were able to use the experiments within the relatively inflexible school schedule and curriculum requirements. Their biggest issue again was time constraints.

Scheduling Issues

I'm lucky to work in a school which allows a great degree of latitude and was able to schedule a "cell unit" around the same time as we had the kit. This, plus the fact that the material and standards aligned helps to justify its use in the classroom

I was able to work with the Microlab during double periods. When I had only one period with a class, I would distribute materials before the arrival of the students, and we would get right to work. Sometimes, instructions would be given on the previous day. Since students were excited with the activities, there were seldom behavior or time management issues.

More Vernier bottles. I see at least 3 classes back-to-back, and washing out the bottles in between each one was difficult, when there's so much else to accomplish in the 40 min period. Also, if each computer had 2 bottles, each student could run the balloon test at the same time as the Probeware test, facilitating a nice comparison.

I used deep well concave slides and I think they work better than using the observation gel. I think it saved a lot of time, too, because making the gel and getting the slide set up uses a lot of time.

I modified my schedule to ensure that I used the cultures while they were still viable. I used lecture time as lab time for the week with the kit. I used some of the materials as review lessons.

I used a stations approach for the protist lab, which worked well. And the bacteria lab, I modified and investigated the effectiveness of different disinfectants.

I did a particular lesson with only some of my classes each day. The next day, I did the lesson with those that missed it.

Kits' Value

Would teachers request the kit again? Just over half (8 in 14) said "yes, definitely," and the rest said "yes, possibly."

Table 44. Request Kits Again

Answer Options	Response Percent	Response Count
Yes, definitely	57.1%	8
Possibly	42.9%	6
No I won't	0.0%	0
	Answered question	14
	Skipped question	0

Conclusions and Implications

Teachers' comments reveal how little hands-on science experience students receive within the school science curriculum and how little support these activities have within most schools' relatively inflexible schedules. The Microlab Kit addresses these issues, but nonetheless, most teachers experienced challenges when trying to take full advantage of what they deemed the Kit's excellent resources. While it was generally agreed that the Kit supplemented the lack of laboratory equipment provided by most schools, teachers said they needed more time to complete the lessons included in the Kit, some of which required longer terms. Teachers devised coping strategies to mitigate the time constraint dilemmas, nonetheless, they would like their students to have more than one week with the kits.

Anecdotal Evidence

Study 9. Final Thoughts

Close to the end of the school year we asked teachers to comment online and share their "final thoughts" about the kit or kits they had used, including any pertinent classroom anecdotes.

Which Activities In The Biotech Kit Were Most Engaging For Students?

The favorite was Delicious DNA, gel electrophoresis, Molymods, Bioterrorism and using micropipettes. In the teachers' words:

Strawberry DNA and electrophoresis

The gel electrophoresis

Materials for delicious DNA

Pipettes

Micro-centrifuge

The Sickle Cell Electrophoresis

All gel electrophoresis activities were very engaging for the students. They were very excited if they were able to use any gel electrophoresis apparatus whether it was to separate dyes or DNA.

Gel electrophoresis, Delicious DNA. My kids could run gels forever....

Doing the gel electrophoresis and the transformation with the "glow" gene

Monkey Pox and the colorful gel practice lab, also the students loved building nucleotides from Molymods

All Gel Electrophoresis, Delicious DNA, Restriction Enzymes, Bioterrorism

My students enjoyed the strawberry DNA lab and the bacterial transformation/glowing germs activity.

Bioterroism, Gel electrophoresis, DNA structure with the the models, Extracting DNA

All of the activities from constructing DNA molecules with the Molymods to the gel electrophoresis were equally engaging for the students.

The creation and use of the gel electrophoresis.

All gels were fascinating to them--including the practice gel with the dyes. They enjoy using the micropipettes and loading gels.

They loved extracting DNA from strawberries and using the Molymods!

My students conduct the intro to gel electrophoresis kit and the sickle cell study. They were very excited to apply what they learned in class to the lab. They were very impressed with the results of the sickle cell study.

DNA structure and function using the plastic strips, micropipetting and running a gel

Students loved the micropippeting of the wells. Especially with the colored dye.

One activity was taking the DNA from the fruit. The teachers around the school told me that the students were walking around with excitement showing the DNA of the banana or strawberries to them and their friends.

Students enjoyed most all components of this kit that we employed, including using the micropipettes, doing the gel electrophoresis, and using the DNA made easy (Carolina?) To manipulate sections of DNA, RNA and Amino acids on the board. We also did the plasmid transformation of E. Coli, which rendered beautiful results. We used the Delicious DNA extraction protocol before even getting our hands on the kit (very off the shelf) and the kids LOVED that.

DNA extraction

Extracting DNA from strawberries was fun. Also, all the gel electrophoresis stuff.

They really enjoyed the Bioterrorism case. I think it held everyone's attention while not being "too close to home" for students with family histories of cancer, and provided a foundation for some very interesting discussions.

Was There Anything In The Biotech Kit That Was Not Successful?

Nine teachers said that everything worked well. Two teachers said they could not say because they had not used all the lessons. The biggest issue was the need for more time to conduct experiments, as these teachers expressed it:

The only issue that I had was I didn't have the kit long enough to do everything that I would have liked to do. I also had no use for the transformation activity because it was more advanced for the students in my class. If I had a higher level of students and more time I would definitely have done it, but it isn't specifically part of the living environment curriculum.

It was difficult to get the lab done, even in two consecutive periods. A lot of my students had questions and needed help, by the time everyone got their gel running it was late. We did not have enough time to analyze the practice gel. They did not store well. Techniques improved for the sickle cell study.

Everything was successful. The only thing that was lacking is time to do all the lessons. We were able to do few but each one was great.

Time was a huge issue for us, and we had to be VERY selective in what we could use from the kits in the time we had them. It's a testament to how rich the curriculum is, but it was tough not to be able to do everything we wanted to! We did the pencil-and-paper restriction enzyme activity, which I really liked, but which may not have been 100% clear to the kids. They got making the first cuts using the first restriction enzyme (Eco RI, if I remember correctly) but were confused when doing the second (Bam?) And then being asked if an gene segment had been isolated. I may not have explained it well, but the last 1/3 of that handout seemed to lose a lot of my kids. A really great activity, but a little complicated, too.

Which Activities In The Microlab Kit Were Most Engaging For Students?

Students enjoyed using the microscopes and seeing the living organisms. They also liked making clay models of the organisms. Teachers wrote:

Students like gathering specimens from bodies of water and looking at them under the microscope. Student also liked the daphnia study but we did not rent flex cams so it wasn't as exciting as it could have been.

Daphnia, Winogradsky column (although this one is delayed in terms of results, since it takes a while to cultivate the niches)

We spent an entire week letting the student work on the environmental effects on the heart rate of Daphnia.

Use of the smithfield microscopes.

Basic microscopy

Use of the high-powered microscope that projected through our LCD projector

Bacterial transformations

I only used the examining heart rate of Daphnia activity with my students, which they found very engaging.

The heart rates of the Daphnia Magma and the effects of the environment on yeast fermentation

They loved using the field microscopes! The videomicroscope was a wonderful addition to the classroom.

Journey into microspace, Induced environmental changes and bacteria

Identifying microorganisms with the swift field microscopes. We used a mixed culture.

They loved the water flea.

The other activity was the gel electrophoresis. Loading the gels with the micropipette was a unique experience. They were very happy to take the gels with them as well. We ended the year with a debate about genetics engineering in which they recalled their biotechnology experience.

In the Microlab kit, the students seemed most engaged by working on the live protist activities, including modeling the organism using Model Magic, and observing and presenting these models to their classmates, the different types of organisms observed. A companion website or recommended info source on protist species might be helpful for factual details. The handbook shown in the training session has gone out of print, so we weren't able to get copies to use in class.

Usage of field microscope

The second grade students loved looking at slides under the swift field microscopes.

Was There Anything In The Microlab Kit That Was Not Successful?

Nine teachers said that everything worked well. There were several problems with the equipment. And time constraints again were an issue, as noted:

No, in fact because of time constraints and the number of classes I held, we left transformations in every single stage over night. Almost none of the classes carried out the transformations exactly as recommended by the procedure and yet each class had gotten some successful transformants.

I personally found the swift field microscopes a bit difficult to use, so I didn't attempt to use them with my students.

The detailed studies of chaos chaos did not work well.

Keeping my darn daphnia alive!!!

The field microscopes were difficult for students to use.

Nothing was not useful - everything we used worked well. The most challenging pieces we worked with, however, were using the microscope camera / adapter setups, and the daphnia lab slides. The two material changes I would suggest would be to swap the camera / scope rig for a USB output microscope (so much easier) and deep well slides instead of the messier protocol outlined in the handbook. The suggestions both worked, but slight modifications might help them work even better.

Nothing specifically- the more open-ended nature made it more difficult to incorporate into the curriculum, however.

I did not have the cables for the video microscope or the adaptor for the projector. (I did manage to use equipment I had.)

The camera was a bit on the fritz when we used it.

Everything was pretty useful

Memories: What Stands Out?

Did anything stand out in teachers' memories regarding using the kits in the classroom? Several teachers were deeply impressed by the "magic" of hands-on activities: slower students often outshone their more studious peers, increasing their motivation and interest in science. The following comments illustrate this point:

The activity was a collaboration between my special education class of living environment students and a general education microbiology class. My students are familiar with technology because I use it in my classroom. They were the first to begin the activity and actually helped the gen ed kids set up equipment. It was great to see otherwise shy and limited students (many are autistic), participate and join groups of strangers and have the confidence to reach out to help them.

My "less scientifically inclined" students got excellent results for the transformation activity--even better than the AP Biology class.

I did the kits with a relatively young group, eighth graders taking Living Environment. What stood out for me was the notion that the students who were highly engaged in the kits were not necessarily the most academically inclined. The students who were most talented at building the models were not the best test takers, and the flip side, some students who enjoy great study skills, had difficulty manipulating the pipette tips into the wells, or looking at a two dimension model and building the three dimension version. This gave often not engaged student a change to shine, and one could see how proud they were of themselves. These students often had immediate solutions to lab situations that would come up that were insightful and outshined the "studyers." It was a great experience for all however.

The kids were really excited to work with the electrophoresis equipment. My lower level kids were actually more respectful and appreciative of it than my higher level.

The students really enjoyed the pipette practice. It was their first experience with the materials, and many of the less studious students found that they were equally or even more so successful with the micropipette; this small success seemed to keep them continuously motivated to participate in discussions in order to be able to conduct the actual assays.

Additional positive comments:

The kids gained a better understanding of gel electrophoresis and gene detection

The kids love hands on materials.. The students wished we could have the material longer.. They felt rushed and/or that some materials should have been presented to them earlier to align with the pace of the class. They had many ah ha moments after using the kit materials.. Many wished this type of understanding could have happened earlier when the material was covered n class

The students really enjoyed learning about the protist in the pond water.

It was a wow moment when students saw the movement of numerous rotifers in samples of water collected from the grounds around the building

The wonder that was inspired by seeing protists swimming across the screen. After about 3 minutes of silence, 20 of 30 hands one by one went up, and we spent the rest of the class period just discussing the thoughtful questions provoked from the experience. For most of my students, this was the first time they ever viewed microorganisms, and this larger-than-life peek into one drop of "beastie"-filled water was like fireworks for them.

Extracting DNA from the strawberries was a very exciting activity for the students because they were all engaged and eager to extract the most amount of DNA from the fruits. Therefore, they were extremely patient and motivated to twirl as much DNA from the solution.

It was great to see the students realize how gel electrophoresis works and their sense of amazement at how that process works.

Using the kits in class was of great value. I teach honors science in a middle school so my living environment students were enriched by the use of the kits.

Most students, when asked at the end of the year about their favorite lab, indicate that this set of labs was their favorite.

I remember how much fun the students had using the Molymods. At first, I had my 6th graders make models of nucleotides. That proved to be too complicated at first, so the next day I had them start by building water, carbon dioxide, etc. Then we worked our way up to bigger molecules. The Molymods are a wonderful tool for introducing molecular structures.

I actually have video footage of my students viewing and identifying microorganisms. It's fabulous to look back and see how engaged they were. You know your kids are fascinated when everyone is calling you to come over and check out what they have in their slide! It's the best!

I was thankful that Tara came to my class during the time I was doing gel electrophoresis. She was extremely helpful specially when I was dealing with the 7th graders.

For me, one of the hidden legacies of the kit is the way they reduce the perceived barriers to doing more materially intensive lab work in the classroom, for both the teachers AND the students. They really expanded my notion of what kind of science was possible in my classroom beyond the dissections and seed germination labs of my own experience to approach a more authentic and rich experience with science. I was especially pleased how the kids noticed materials they had worked with (micropipettes, eppendorf tubes, etc.) When later viewing media clips on TV. Oh....and in cleaning out my room at the end of the year, I was pleased to see that a few of the Daphnia had somehow survived for months in the classroom, unattended in their little jar....too cool.

I used baking soda and vinegar to show my second grade students how the mixture can blow up a balloon. The children loved this activity.

Students were crazy to track down the DNA pattern. They were so involved that it's hard to believe.

<u>A couple of not-so-positive comments</u>

It was hard to dissolve the caffeine pill and see the Daphnia clearly under the microscope because big chunks of the undissolved caffeine would be in the way. Students liked the smell of the strawberry "mash" before it was filtered.

One of the groups spilled their setup when they were getting ready to plug in the apparatus.

<u>A few unserious memories</u>

The student who wrote , "I did not know that we could extract DNA from fruits." We made necklaces using the extracted DNA and the students kept them for days. They still talk about the labs.

Students were so, so nervous and careful about pipetting -- I've never seen them take that much care for anything!

Delicious DNA- when we brought the elementary kids in to do this activity- the high school students teaching them still had THEIR DNA bracelets & necklaces from when they did the activity 6 months prior!

I broke the leg on a gel box by accident. I felt so foolish.

Overall Conclusions and Implications

Teacher Training and Impact Utilizing Health Science Portable Laboratories, a two-year SEPA Phase II collaboration between Columbia University (CU) and the New York Hall of Science (NYHoS), succeeded in meeting its primary goal:

- To enhance science teaching and learning through the use of portable laboratories and hands-on modules.

NYHoS education staff conducted teacher training workshops at the Hall on two types of kits—portable laboratories that were developed for teachers to bring hands-on lessons into their classrooms. One of the kits was designed for studying biotechnology and the other microscopy. Included in the training program was a visit by a NYHoS educator on the first day a teacher used a kit in his or her classroom, to ensure that the teacher was comfortable using the equipment.

Teacher training in curriculum programs enhanced by portable laboratories with hands-on modules proved highly effective in the following areas:

- Teachers' ability to teach the curriculum;
- Teachers' perception of the value of the portable laboratories used in their classes;

Unfortunately the final objective of this evaluation—measuring the relative knowledge gain of students who were exposed to the portable labs with teachers trained in their use, compared to students who studied the same curriculum but without the additional modules—proved impossible to perform. The reasons for this omission include:

1. It would be unfair and unethical to create a control group who did not receive the treatment (kits in class) in order to measure their effectiveness;
2. Institutions outside the BOE are not permitted to come into schools to test students.

Overall, findings from nine separate studies indicate that the kits are a valuable resource for science teaching and learning, supplementing the lack of hands-on experiences in the schools' science curriculum.

Appendix A. Non-Regents Courses Taught

Biotech Teachers

Middle School

Earth Science
Eighth grade science
General Science (Spiral)
General Science
Possible spiral program 8th grade
6, 7, 8th grade spiral
Living Environment
Earth Science, physical science, biology, general science
8th grade general science, environmental science
Living Environment and Technology
Grade 7 Science
5th & 6th General Science
6th grade science
General Science 5,6,7,8 Special ed 5,6,&8
General 6th/7th
7th Grade Spiral Curriculum PBIS
Life and Physical and Earth Science
Living Environment

High School

Biology
AP Environmental Science, Env. Science
Intro to LE
Forensics
Advisory
12th Grade Bio advanced
Health Occupations
Mathematics, science research, technology
Science research
Biochemistry
Forensics
Marine Science
philosophy, psychology, SSR, Advisory
Environmental Science
science research
Living Environment
Forensics
environmental science biology
AP Chemistry, Forensic Science
Environmental Seminar
AP Biology
Chem in the Comm., AP Env. Science
Advanced Biology
AP Environmental Science
AP Biology
Science Research

Microlab Teachers

Middle School

Life, physical & earth (spiral)- 7 & 8
Living Environment
Life Science, Earth Science, Physical Science (5)
General Science (9)
Spiral 8th Grade Science
Intermediate level science test
Earth Science

High school

Globe Science
Chemistry, Liven (Lab), Earth Science, Computers
Science Research
Environmental Science (2)
AP chemistry,
The Living Environment (3)
Earth science, Life science, physics & chem. sc.
AP Biology (2)
Marine Biology (2)
AP Biology, AP Environmental Science
Biology
Science Research
Forensics (3)

Appendix B. Professional Development Courses Taken

Biotech kit trainees
2006 (some 2007)
Developing portfolios in 8th grade/AMNH Evolution
2007 NEEDS organization; energy. my health, my environment through SUNY Stonybrook, U of Rochester
SIOP/different instrument
SIOP literacy training
QTEL, 2007 Cold Spring Harbor Biotechnology
NYHOS Biotech lab
Columbia University Summer Research, National Parks Service
Urban advangate, NYHOS and other institutions
2007 Columbia Summer Research Program
Differentiated Instruction
07 Columbia Summer Research Program
Strengthening Forensic Science
AMNH Moveable Museum Discovering Paleontology, Title IID Intergrating Technology in the Classroom @Touro College
Biotechnology Seminar at Hunter College
Scaffolding the use of academic English for ELLs
Differentiated Instruction
Technology in the classroom
Partners in Science, electronic gradebook
STANYS
The Ocean System - online course through AMNH PWISTA-Bio
too many to list
Columbia U. Summer Science Research
Columbia University's Science Teacher Research Program
Strengthening Inquiry skills
DNAmazing
Family Secrets
Saturday Science - Hall of Science
Excel
TRUST
UA
AMNH Spitzer Hall of Origins
Teaching Tolerance to Middle School / Lab tops 1&2 / TV Production 1&2 / Computer in the classroom / Plastic Technology / Science and Math Music
Teaching Tolerance to Middle School, Laptop 1&2, TV Production 1&2, Sign Lang. 1
February - Starlab - Hall of Science (2007-Math KDSI online)
Wave Hill Kerlin Institute, Managing A Successful Classroom, Vocabulary in the Classroom
Biotechnology at Hunter College
Urban Advantage, Publishing Projects w/Appleworks, Dana Brain series, Region 3 science

2005
Biopad gene ??Gel electrophoresis
Columbia Summer Research
Columbia University, DOE Courses
Urban advangate, NYHOS and other institutions
NYHOS StarLabII, AMNH Einstein Exhibit, AMNH Moveable Museum.
Coach's training for science olympiad
Workshop model of Teaching by the NYCBOE
BOCES chemistry inquiry
STANYS, NSTA
Don't remember - something related to classroom management
Columbia U. Summer Science Research
Hards on Chemistry, Reading/Writing Across Curriculum
Wiel Medical College Problem-Based Learning Series
NJ Science Convention
DNA - Bio Tech Training and syllabus writing w/s
Bio-nano technology
Research in the classroom
UA
TRUST, UA
Nanobiotechnology at Cornell (NBTA)
July - R+W Project - Teacher's College
Differentiated Instruction, Aligning Curriculum and Standards, CSIT workshop
Using the Museum in the CRoom
Region 5 science training

2004
Columbia Summer Research
Urban advangate, NYHOS and other institutions
AMNH Teaching Diverse Learners (1year Program) Title IID Intergrating Science and Technology
Space, Time and Motion-- "Seminars on Science" program through the Museum of Natural History
Co-teaching strategies in the classroom.
Cornell CIBT's
CIBT
Biotechnology @ Dolan DNA
USDA Teach Program - Costa Rica
PSE&G Energy assessment
Brain MRI
Weill Inst. - monthly workshops
Globe
UA Globe
Too many to fill out but not directly related to DNA
Quality Teaching for English Language Learners
Region 5 science training

2003
NYHOS StarLab, NYHOS MicroLab, Liberty Science Center Space Lab
Co-teaching in the classroom
Masters Degree in science education (workshops were included in the program)
STANYS
CIBT
Active physics
Writers Workshop
Writers Workshop
Digital Media in the CR
2002
GISS NASA
Texas Instruments Master Certificate (Teachers Teaching with Technology)
Master in science education (workshops were included in the program)
PATCH - Forensics

Microlab Kit trainees
2006 (12 teachers)
Reading and writing project/biotech (2007)
Putting the Art in the Language Arts Standards
Trust at the American Museum of Natural History
Intro to Excel
Biotech Lab, AppleWorks, Region 3 Science Professional Development, Urban Advantage Literacy, Science
U.A. 2007 BioTech Lab, Dana Brain
Science Intervention
America's Choice Science Institute
Hall of Science-Saturday Science
Biotech Lab, Dana Brain, Science Region 3 training, AppleWorks
Laser academy at qbcc

2005 (12 teachers)
Reading and writing project
Dolan DNALC Biotech summer program, region 7 science workshops, reading and writing science
Art Across the Curriculum
Urban Advantage
Cornell Series of monthly courses
Mathematics
U.A., TRUST
Genetics Based PBL
America's Choice Science Institute
American Museum of Natural History - Evolution workshops
Science Region 5 training
Developing multiple intelligences

2004 (7 teachers)
Reading and writing project

Elementary Italian
Science
U.A
Microscopy
Cooperative Discipline
Cooperative learning

2003 (5 teachers)
Project Smart
Writing
Using the 5 E Model in Science
Mentoring
Teaching In Multiculture Environment

2002 (2 teachers)
New Teacher Development
Teaching Active Physics

Appendix C. Comparison of CU and Non-CU Teachers' Skills and Knowledge

Biotech Trainees: Baseline Knowledge

Table 45. Rate Skills and Knowledge

DNA structure and function	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	2.7%	1	1.8%	1
Minimal	5.3%	1	18.9%	7	14.3%	8
Average	15.8%	3	35.1%	13	28.6%	16
Above Average	52.6%	10	24.3%	9	33.9%	19
Extremely Knowledgeable	26.3%	5	18.9%	7	21.4%	12
Total	100.0%	19	100.0%	37	100.0%	56

Table 46. Rate Skills and Knowledge

Punnet Squares	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	5.3%	1	5.4%	2	5.4%	3
Minimal	-	-	5.4%	2	3.6%	2
Average	26.3%	5	24.3%	9	25.0%	14
Above Average	47.4%	9	32.4%	12	37.5%	21
Extremely Knowledgeable	21.1%	4	16.2%	6	17.9%	10
Total	100.0%	19	100.0%	37	100.0%	56

Table 47. Rate Skills and Knowledge

Gel Electrophoresis	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	5.6%	1	18.9%	7	14.5%	8
Minimal	5.6%	1	29.7%	11	21.8%	12
Average	33.3%	6	27.0%	10	29.1%	16
Above Average	22.2%	4	13.5%	5	16.4%	9
Extremely Knowledgeable	33.3%	6	10.8%	4	18.2%	10
Total	100.0%	18	100.0%	37	100.0%	55

Table 48. Rate Skills and Knowledge

Centrifuging	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	5.3%	1	10.8%	4	9.1%	5
Minimal	-	0	29.7%	11	20.0%	11
Average	36.8%	7	24.3%	9	29.1%	16
Above Average	26.3%	5	18.9%	7	21.8%	12
Extremely Knowl.	31.6%	6	16.2%	6	21.8%	12
Total	100.0%	19	100.0%	37	100.0%	56

Table 49. Rate Skills and Knowledge

Micropipetting	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	5.3%	1	18.9%	7	14.3%	8
Minimal	-	-	27.0%	10	17.9%	10
Average	31.6%	6	21.6%	8	25.0%	14
Above Average	31.6%	6	16.2%	6	21.8%	12
Extremely Knowl.	31.6%	6	16.2%	6	21.8%	12
Total	100.0%	19	100.0%	37	100.0%	56

Table 50. Rate Skills and Knowledge

Restriction Enzymes	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	5.3%	1	29.7%	11	21.8%	12
Minimal	5.3%	1	24.3%	9	17.9%	10
Average	47.4%	9	21.6%	8	30.6%	17
Above Average	31.6%	6	10.8%	4	17.9%	10
Extremely Knowl.	10.5%	2	13.5%	5	12.5%	7
Total	100.0%	19	100.0%	37	100.0%	56

Table 51. Rate Skills and Knowledge

Gene Transformation	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	5.6%	1	25.0%	9	18.5%	10
Minimal	11.1%	2	30.6%	11	24.1%	13
Average	33.3%	6	19.4%	7	24.1%	13
Above Average	44.4%	8	16.7%	6	25.9%	14
Extremely Knowl.	5.6%	1	8.3%	3	7.4%	4
Total	100.0%	18	100.0%	36	100.0%	54

After Biotech Training

Table 52. Rate Skills and Knowledge

DNA structure and function	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	-	-	-	-
Average	-	-	16.7%	4	7.8%	4
Above Average	48.1%	13	50.0%	12	49.0%	25
Extremely Knowledgeable	51.9%	14	33.3%	8	43.1%	22
Total	100.0%	24	100.0%	27	100.0%	51

Table 53. Rate Skills and Knowledge

Punnet Squares	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	4.2%	1	2.0%	1
Average	3.7%	1	16.7%	4	9.8%	5
Above Average	33.3%	9	29.2%	7	31.4%	16
Extremely Knowledgeable	63.0%	17	50.0%	12	56.9%	29
Total	100.0%	24	100.0%	27	100.0%	51

Table 54. Rate Skills and Knowledge

Gel Electrophoresis	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	-	-	-	-
Average	11.1%	3	16.7%	4	13.7%	7
Above Average	33.3%	9	54.2%	13	43.1%	22
Extremely Knowledgeable	55.6%	15	29.2%	7	43.1%	22
Total	100.0%	24	100.0%	27	100.0%	51

Table 55. Rate Skills and Knowledge

Centrifuging	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	-	-	-	-
Average	7.4%	2	8.7%	2	8.0%	4
Above Average	29.6%	8	56.5%	13	42.0%	21
Extremely Knowledgeable	63.0%	17	34.8%	8	50.0%	25
Total	100.0%	23	100.0%	27	100.0%	50

Table 56. Rate Skills and Knowledge

Micropipetting	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	-	-	-	-
Average	3.7%	1	8.3%	2	5.9%	3
Above Average	29.6%	8	54.2%	13	41.2%	21
Extremely Knowledgeable	66.7%	18	37.5%	9	52.9%	27
Total	100.0%	24	100.0%	27	100.0%	51

Table 57. Rate Skills and Knowledge

Restriction Enzymes	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	8.3%	2	3.9%	2
Average	18.5%	5	20.8%	5	19.6%	10
Above Average	40.7%	11	37.5%	9	39.2%	20
Extremely Knowledgeable	40.7%	11	33.3%	8	37.3%	19
Total	100.0%	24	100.0%	27	100.0%	51

Table 58. Rate Skills and Knowledge

Gene Transformation*	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	9.1%	1	2.6%	1
Average	14.8%	4	9.1%	1	13.2%	5
Above Average	51.9%	14	45.5%	5	50.0%	19
Extremely Knowll	33.3%	9	36.4%	4	34.2%	13
Total	100.0%	27	100.0%	11	100.0%	38

*Activity not included in 2 workshops

Microlab Trainees: Baseline Knowledge

Table 59. Rate Skills and Knowledge

Rate your skill/knowledge in using microscope					
	None	Minimal	Average	Above Average	Extremely Knowledgeable
Columbia N=11	0.0%	0.0%	9.1%	81.8%	9.1%
Others N=34	2.9%	11.8%	29.4%	32.4%	23.5%

Table 60. Rate Skills and Knowledge

Rate your skill/knowledge in using deep-well slides					
	None	Minimal	Average	Above Average	Extremely Knowledgeable
Columbia N=11	0.0%%	18.2%	54.5%	27.3%	0.0%
Others N=33	24.2%	21.2%	27.3%	18.2%	9.1%

Table 61. Rate Skills and Knowledge

Rate your skill/knowledge in using videomicroscope					
	None	Minimal	Average	Above Average	Extremely Knowledgeable
Columbia N=11	9.1%	36.4%	36.4%	18.2%	0.0%
Others N=32	43.8%	31.3%	21.9%	3.1%	0.0%

Table 62. Rate Skills and Knowledge

Rate your skill/knowledge in using video camera					
	None	Minimal	Average	Above Average	Extremely Knowledgeable
Columbia N=11	9.1%	9.1%	63.6%	18.2%	0.0%
Others N=33	9.1%	24.2%	39.4%	27.3%	0.0%

Table 63. Rate Skills and Knowledge

Rate your skill/knowledge in using projector					
	None	Minimal	Average	Above Average	Extremely Knowledgeable
Columbia N=11	0.0%	9.1%	36.4%	45.5%	9.1%
Others N=34	14.7%	11.8%	26.5%	26.5%	11.8%

Table 64. Rate Skills and Knowledge

Rate your skill/knowledge in using MacClade software					
	None	Minimal	Average	Above Average	Extremely Knowledgeable
Columbia N=11	81.8%	18.2%	0.0%	0.0%	0.0%
Others N=32	82.9%	8.6%	0.0%	0.0%	0.0%

Table 65. Rate Skills and Knowledge

Rate your skill/knowledge in using PAUP (Phylogenic Analysis Using Parsimony) software					
	None	Minimal	Average	Above Average	Extremely Knowledgeable
Columbia N=11	81.8%	9.1%	0.0%	9.1%	0.0%
Others N=32	93.8%	6.3%	0.0%	0.0%	0.0%

Table 66. Rate Skills and Knowledge

Rate your skill/knowledge in using Vernier Probeware (Logger Pro, Lab Pro Unit, CO2 Sensors)					
	None	Minimal	Average	Above Average	Extremely Knowledgeable
Columbia N=11	27.3%	27.3%	27.3%	18.2%	0.0%
Others N=33	65.6%	25.0%	12.5%	0.0%	0.0%

Table 67. Rate Skills and Knowledge

Rate your skill/knowledge in using Clear O ne Flex Cam					
	None	Minimal	Average	Above Average	Extremely Knowledgeable
Columbia N=11	27.3%	45.5%	27.3%	0.0%	0.0%
Others N=33	81.3%	9.4%	6.3%	6.3%	0.0%

Table 68. Rate Skills and Knowledge

Rate your skill/knowledge in using iMovie					
	None	Minimal	Average	Above Average	Extremely Knowledgeable
Columbia N=11	45.5%	36.4%	9.1%	9.1%	0.0%
Others N=33	57.6%	36.4%	6.1%	0.0%	0.0%

Table 69. Rate Skills and Knowledge

Rate your skill/knowledge in using iPhoto					
	None	Minimal	Average	Above Average	Extremely Knowledgeable
Columbia N=11	36.4%	45.5%	9.1%	9.1%	0.0%
Others N=33	54.5%	36.4%	6.1%	0.0%	3.0%

Table 70. Rate Skills and Knowledge

Rate your skill/knowledge in using live microorganism cultures						
	None	Minimal	Average	Above Average	Extremely Knowl'able	Don't Know
Columbia N=11	0.0%	9.1%	54.5%	27.3%	9.1%	0.0%
Others N=33	15.2%	21.2%	27.3%	24.2%	9.1%	3.0%

Table 71. Rate Skills and Knowledge

Rate your skill/knowledge in using yeast CO_2 production						
	None	Minimal	Average	Above Average	Extremely Knowl'able	Don't Know
Columbia N=11	0.0%	18.2%	54.5%	27.3%	0.0%	0.0%
Others N=32	31.3%	21.9%	21.9%	15.6%	6.3%	3.1%

Table 72. Rate Skills and Knowledge

Rate your skill/knowledge in using chaosC amoeba						
	None	Minimal	Average	Above Average	Extremely Knowl'able	Don't Know
Columbia N=11	27.3%	63.6%	9.1%	0.0%	0.0%	0.0%
Others N=33	57.6%	21.2%	15.2%	3.0%	0.0%	3.0%

Table 73. Rate Skills and Knowledge

Rate your skill/knowledge in using daphnia magna						
	None	Minimal	Average	Above Average	Extremely Knowl'able	Don't Know
Columbia N=11	18.2%	45.5%	27.3%	9.1%	0.0%	0.0%
Others N=33	51.5%	27.3%	12.1%	6.1%	0.0%	3.0%

Table 74. Rate Skills and Knowledge

Rate your skill/knowledge in plating bacteria with antibiotics						
	None	Minimal	Average	Above Average	Extremely Knowl'able	Don't Know
Columbia N=11	9.1%	9.1%	27.3%	36.4%	18.2%	0.0%
Others N=33	45.5%	21.2%	9.1%	12.1%	6.1%	6.1%

After Microlab Training

Table 75. Rate Skills and Knowledge

Microscope	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	9.1%	1	-	-	2.4%	1
Minimal	-	-	-	-	-	-
Average	-	-	12.5%	4	9.5%	4
Above Average	45.5%	5	31.3%	10	35.7%	15
Extremely Knowl.	36.4%	4	56.3%	18	52.4%	22
Total	100.0%	10	100.0%	32	100.0%	42

Table 76. Rate Skills and Knowledge

Deep-Well Slides	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	-	-	-	-
Average	10.0%	1	25.0%	8	21.4%	9
Above Average	20.0%	2	25.0%	8	23.8%	10
Extremely Knowl.	54.5%	6	50.0%	16	52.4%	22
N/A	9.1%	1	-	-	2.4%	1
Total	100.0%	24	100.0%	32	100.0%	42

Table 77. Rate Skills and Knowledge

Videomicroscope	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	3.1%	1	2.4%	1
Average	30.0%	3	31.3%	10	31.0%	13
Above Average	40.0%	4	28.1%	9	31.0%	13
Extremely Knowl.	30.0%	3	37.5%	12	35.7%	15
Total	100.0%	24	100.0%	32	100.0%	42

Table 78. Rate Skills and Knowledge

Video Camera	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	-	-	-	-
Average	30.0%	3	35.5%	11	34.1	14
Above Average	40.0%	4	25.8%	8	29.3%	12
Extremely Knowl.	30.0%	3	29.0%	9	29.3%	12
N/A	-	-	9.7%	3	7.3%	3
Total	100.0%	10	100.0%	31	100.0%	41

Table 79. Rate Skills and Knowledge

Projector	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	-	-	-	-
Average	-	-	28.1%	9	21.4%	9
Above Average	45.5%	5	31.3%	10	35.7%	15
Extremely Knowl.	45.5%	5	40.6%	13	42.9%	18
Total	100.0%	10	100.0%	32	100.0%	42

Table 80. Rate Skills and Knowledge

Vernier Probeware	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	-	-	-	-
Average	40.0%	4	35.5%	11	36.6%	15
Above Average	40.0%	4	35.5%	11	36.6%	15
Extremely Knowl.	20.0%	2	25.8%	8	24.4%	10
N/A	-	-	3.2%	1	2.4%	1
Total	100.0%	10	100.0%	31	100.0%	41

Table 81. Rate Skills and Knowledge

Clear One Flex Cam	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	-	-	-	-
Average	-	-	30.0%	9	22.5%	9
Above Average	70.0%	7	26.7%	8	37.5%	15
Extremely Knowl.	30.0%	3	40.0%	12	37.5%	15
N/A	-	-	3.3%%	1	2.5%	1
Total	100.0%	10	100.0%	30	100.0%	39

Table 82. Rate Skills and Knowledge

iMovie	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	10.0%	1	3.1%	1	4.8%	2
Average	30.0%	3	43.8%	14	40.5%	17
Above Average	30.0%	3	21.9%	7	23.8%	10
Extremely Knowledgeable	30.0%	3	28.1%	9	28.6%	12
N/A	-	-	3.1%	1	2.4%	1
Total	100.0%	10	100.0%	32	100.0%	42

Table 83. Rate Skills and Knowledge

iPhoto	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	10.0%	1	6.7%	2	7.5%	3
Minimal	-	-	12.3%	4	10.0%	4
Average	30.0%	3	33.3%	10	32.5%	13
Above Average	20.0%	2	10.0%	3	12.5%	5
Extremely Knowl.	30.0%	3	23.3%	7	25.0%	10
N/A	10.0%	1	13.3%	4	12.5%	5
Total	100.0%	10	100.0%	30	100.0%	40

Table 84. Rate Skills and Knowledge

Live Organism Cultures	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	6.3%	2	4.8%	2
Average	30.0%	3	21.9%	7	23.8%	10
Above Average	50.0%	5	43.8%	14	45.2%	19
Extremely Knowl.	20.0%	2	28.1%	9	26.2%	11
Total	100.0%	10	100.0%	32	100.0%	42

Table 85. Rate Skills and Knowledge

Yeast CO_2 Production	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	-	-	-	-
Average	10.0%	1	21.9%	7	19.0%	8
Above Average	70.0%	7	43.8%	14	50.0%	21
Extremely Knowledgeable	20.0%	2	34.4%	11	31.0%	13
Total	100.0%	10	100.0%	32	100.0%	42

Table 86. Rate Skills and Knowledge

Chaos Chaos Amoeba	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-	-	-	-	-
Average	60.0%	6	31.3%	10	38.1%	16
Above Average	30.0%	3	50.0%	16	45.2%	19
Extremely Knowledgeable	10.0%	1	18.8%	6	16.7%	7
Total	100.0%	10	100.0%	32	100.0%	42

Table 87. Rate Skills and Knowledge

Daphnia Magna	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	-	-	-	-
Minimal	-	-				
Average	10.0%	1	25.0%	8	21.4%	9
Above Average	80.0%	8	53.1%	17	59.5%	25
Extremely Knowledgeable	10.0%	1	21.9%	7	19.0%	8
Total	100.0%	10	100.0%	32	100.0%	42

Table 88. Rate Skills and Knowledge

Plating Bacteria	Columbia Teachers		Other Teachers		Total Teachers	
	Percent	Frequency	Percent	Frequency	Percent	Frequency
None	-	-	3.1%	1	2.4%	1
Minimal	-	-	-	-	-	-
Average	40.0%	4	15.6%	5	21.4%	9
Above Average	40.0%	4	43.8%	14	42.9%	18
Extremely Knowl.	20.0%	2	25.0%	8	23.8%	10
N/A	-	-	12.5%	4	9.5%	4
Total	100.0%	10	100.0%	32	100.0%	42

Appendix D. Open Responses

Teachers' Assessment of Biotech Training

Question 2. How closely did the training meet your expectations? Please explain your answer: what did you expect and how did the training compare?

Great hands-on activities

I expected to come away with some activities that were well developed for my classroom and that I was test-running before I used them. This truly helped bring the biotech I used all summer in the lab simply into my classroom.

I was impressed by how much hands-on experience we had. This helped to keep us all involved. The activities were relevant, creative and applicable.

Very hands-on oriented to practice what I will now have to "lead" in my classes

I knew that I would learn the techniques taught. I also knew that the workshops would be hands-on, I didn't expect to have so much fun.

I was expecting for hands-on and exciting activities which were all done in the seminar.

It was well done. I relearned some stuff and was given some very good ideas for future experiments.

I never predicted that there would be so much interactive activities

I was extremely happy that we were able to have hands-on activities. I expected to write lesson plans about genetics.

I found very interesting topics and ways to teach in a class.

The book and materials are very good to follow and great to use for my students who are just learning about DNA.

I was already familiar with the materials and technology on demo from prior experience, but the strength of the training was in the ideas presented for translating that personal understanding to students

I expected lots of practicable activities and training on technology and that's what we got. The reason I say better is the teaching activities. The gel electrophoresis & DNA made easy were fantastic and I'll use them.

Hands-on demo. Applied content to lab activity which leads to reinforcement of concepts.

I expected much less equipment and activities. The amount of material covered was impressive.

Enough practice in preparing and running gels. Practice in interpreting gels.

I expected to get a hands on experience with this workshop.

I learned a lot

I am very happy being here. I learned a lot that I could learned in last five years.

Manual is much more detailed - great background, good reinforcement of techniques, good models to use - tangles, DNA strips, restriction enzyme wheels

I expected to learn about Biotechnology and the lab techniques involved. I found the workshop to be very useful!

The background information on each activity is useful and important.

The training provided me with an in depth study of DNA that I am not familiar with. My science training was many years ago even the tools we used were different. It was great that I was able to use more currently materials.

I expect learn strategies fitted for my students to teach DNA but I learned more than that. Because it really widen and enhances my knowledge of it too.

There was a lot of valuable information that has help me as a student and a teacher. In addition, the genetic counselor brought in some great debatable information that can be used to stimulate scientific inquiry and promote collaboration amongst the students.

Better because it not only met my expectations but I also learned new things in small pox.

I thought it was going to be somehow differently but it helped develop my research skills further.

The trainer was very knowledgeable, which was awesome & isn't always the case. I learned and felt that we weren't treated like kids.

I expected it to be interesting, but I learned much more than expected.

Comments on level and focus of instruction

I thought that the skills would have been addressed more quickly - at times it was tedious to run 3 gels.

I liked the pace and the different instructors.

I knew that the kits would be useful if they were developed here, however I was continually impressed by the thoughtfulness behind the activities. While many of the approaches are similar to those I've employed, I think your level of preparation will elevate my teaching.

I don't know what I expected but I was impressed by the discussion of teaching techniques and focus on classroom issues. I am still interested in learning more about how to do a lot of the prep that is done for when you receive the kit in my classroom by myself

It was about what I expected. Some of the training wasn't as necessary since we had experience from Columbia.

I thought that I would have to know more about the whole process in order to succeed but what I found was that even a teacher with very little background could succeed in this course ex. A Physics teacher or an elementary science teacher

The level of info was detailed and offered something for everyone at any level. I left feeling competent and able to perform the tasks. Also, the different types of learning was great. Brainstorming, posters, a visit from a counselor made it multidimensional and entertaining.

Most workshops I go to teach me very little I didn't know before. This is one of the few where I was challenged and incredibly excited to learn more. I've been telling everyone about how amazing this workshop has been.

I expected basic activities but the course went in depth and was extremely informative.

I expected to learn how to use the materials in the kit. Enjoyed the fact that it was hands on and not all lecture.

The training was intense and very hands on. At times the activities jumped a bit too much, and since we ran several gels and analyzed a lot I became confused.

Other

This training was excellent. It was fast-paced and informative. Very enjoyable.

Very interesting

I expected to really be bored because 9-3 (M-S) but I was not. Very good

For DNA instruction; preparation for Regents.

I took the prototype to this training 2 years ago. This provided a manual with more clarification of how to use the equipment with students of varying ability levels.

Question 3: Overall, how was the level of the science content for you?

Everything way cool

Although I studied the topic before, it was not fresh in my mind. This program actually motivated me to think about the topic and share it with my class.

It was good because it was aimed at what our students should learn from it.

I liked that there were different LEVELS of content w/in. So while not every student could handle concatamers, the challenge still existed for those that can.

Some are simple and some are too advanced

Good job at teaching to various levels. I would feel comfortable bringing all activities into my AP and general ed classes.

I loved that it was so advanced, just have to admit that having no background in this made it a little more difficult.

Am a PE teacher, but was a great experience

It was presented clearly and at different levels so we all can use the information.

The gels and pipetting were skills I already knew.

In general it was a review, and on the first day I thought it would be too redundant, however, I found it helpful to hear and think of the questions my students may pose.

I do have some lab background many years ago but even without that I think it would be good

A good review.

The level of content was beyond what I will be teaching, however I found it helpful for me to understand the background biology.

Just the detail of plasmids was beyond curriculums

Some of the material, especially "restricting enzymes" was a bit mind jarring but after discussions and further reading in biotech lab manual, I feel comfortable with the ?.

Question 6: How could we improve the training?

Teachers' suggestions for improving the training

I think linking plasmids info could be presented a little more VISUALLY with the cuts.

Maybe give a small background packet with some of the basics that would be useful for teachers to know to understand all the activities well.

Supply all teachers with their own kits instead of a stipend.

On occasion we did have to rush a bit to cover the scope of content covered. The trade off is between efficiency and saturation.

Bring in a PCR. It would be great to extract & amplify our own DNA.

I guess more adaptations for middle schoolers.

Except why 2 (?) (?) On p 53 activity. Why looking at Human DNA not viral in Bioterrorism activity.

Perhaps it would be helpful to group teachers by grade level (middle vs. HS) to discuss pedagogy or what can be modified for younger students.

In the event that you have several participants who do not have biotech experience, you may want to suggest that they partner with more experienced participants earlier in the training (although the help of the staff was more than enough to keep us on schedule in this group).

Divide the training cohort into groups so one group does sickle cell activity one group cancer, one group bioterrorism

Too long - 6 days is a bit much

Shorten the days. Instead of six days make it 5 days

Shorten the amount of days for the training - it was tiring

Instructors were great - enthusiastic and clear - I would just like to have a scientist present as well.

Let us in earlier. I waited 15 min. In the cold between 8:15-8:30.

Provide longer sessions with more practice. Some (?) Were already prepared for us - some time.

More time!

More viewing boxes - so it doesn't bottleneck.

Bring more animation or visuals along with the lessons.

Streamline the gels - have each table run a different gel. Table 1-cancer. Table 2-sickle cell. Table 3-Bioterror. Go over analysis of each with whole group.

More practice round to shorten tasks. Successive approximations. More drilling of basic, redundant concepts. Not that we don't get it, but we should practice writing out "experimental sketches" to reinforce understanding.

I have to wait and see what happens when I go to use the materials in my classroom

Maybe include some websites for each of the difficult concepts so that students could be directed to these specific websites

Good interaction w/us - discussion of science topics

I thought that the instructions were very clear.

Show some videos ?

Everything was on target

Provide dessert. It was very well organized and went smoothly. The classroom tips were helpful.

The training was excellent. I was hoping to take it as a 3 P Credit course. I enjoyed it anyway.

Off-hand, I can't think of much. I like to hear about the history of science, so maybe a little booklet on the background for some stuff we did, like PCR.

I really like everything, so I wouldn't change anything at all.

It was good having students explain results not just the instructor.

I thought there was ample opportunities to practice new skills learned during the training.

Everything was great.

It was great.

Question 9: How do you plan to use the Biotech kit in your teaching?

<u>With my students</u>

I hope to use the kits to implement several of these activities with my students - I wish I could keep the kits for a month to do all of the activities.

I would like to use for my living environment classes when teaching DNA and genetics lessons

After teaching DNA and genetics I'll use this to teach how biotechnology is used in real life situations - reinforce DNA/genetics info

(Gr. 6) I plan to introduce DNA, use molymeds to show molecular structure, discuss lab techniques: micropipetting, demonstrate gel electrophoresis, interpret gels w/students.

To fully explore the Biotech unit in AP Bio, and LE

I will be doing a biotech unit in my classes.

Reinforce the concept of DNA structure, protein synthesis. Introduce gel electrophoresis technique to prepare them for the Biodiversity state lab.

To have a biotechnology week. DNA structure leads to DNA analysis, DNA transformation (for apes). Chemistry activities and protocols.

I would like to use it to enhance my forensic science classes and to help prepare my living environment students for the regents exam

Delicious DNA, glowing genes etc, and other activities to supplement DNA unit. Also, nice to have equipment and supplies maintained by someone else.

I will use the biotech kit in my teaching to provide the hands-on experience for my students that will help them to understand the biotechnology concepts.

I will teach DNA since CSI is so popular! My kids are so curious!

Use the equipment to reinforce concepts on DNA, gel electrophoresis, crime scene investigation.

In my living environment class and a forensics class.

DNA tangles and strips, Infectious diseases, delicious DNA, gel electrophoresis for Punnett squares

To teach students in transformation. Restriction enzymes, and genetic diseases

I plan to introduce it early by creating interest in 3 people who have issues. Make up characters and post their photos. I will hopefully have discussed biotechnology before hand.

DNA, infection detection!

I plan to teach my students gel electrophoresis techniques and restriction enzymes.

I will use the kit in our experiments by doing demo teaching.

Do a many experiments as possible.

I plan to use it during our unit on life. Kids often bring up DNA because they hear about it but know nothing about DNA. After this workshop it will be great to go more deeply into it.

Lab

For my research and LE clas on the genetic section.

Certain activities such as fingerprinting will be used with my students.

To introduce a topic or maybe reinforce their knowledge.

Gel electrophoresis analyzing DNA structure.

As a form of assessment with my students or to further take my students to the next level of understanding.

I will be using it with my freshman Biology and I will go into the living environment lab of my colleagues.

To enrich the students when I am teaching Biology.

By the time we've reserved the kit, we will have covered chromosomal genetics, but not at the molecular level. The molymod and DNA made-easy will set up the unit, the electrophoresis will teach an application, and the transformation will spiral/extend it.

As part of Mol. Gen & Biotech unit.

It will be the backbone of our DNA unit. The labs will be done and then the results will support all the material pertaining to DNA

Sections & instruction dealing with climate and disease.

I plan on extracting DNA, discussing disease & genetics. Definitely want to teach my kids how to micropipette.

I intend to incorporate the kit during my genetics unit.

As lab activities and re-teaching practices in genetics unit.

Extracurricular

I will incorporate the lessons into my lecture class (I do not teach my students their lab) with the exception of the optional lesson. My plan for the glow genes activity is to run it as an after-school extension for interested students (and those in need of credit for a missed assignment).

I will use it as a workshop week for the 8/9/10th grade researchers, AND work with a teacher of 3 LE classes - I'll team teach them in those classes (since my research schedule is not restrictive)

With Teachers

I plan to do at least 8 of the Labs over the 2 wk period. I plan to invite one other teacher to share in my class labs by bringing her small class to join one of my small classes.

Enrichment/reinforcement

Reinforcement/application of written knowledge students are expected to have.

To supplement the scope and sequence lessons that I teach.

I either plan to use it as an enrichment activity or to reinforce and introduce ideas and concepts. It will motivate students.

Enrichment

I hope to teach it to my 8th grade students. Unfortunately, I see the class a double period a week. I am planning to have a number of students for an after school program along with the class period.

As a hands-on extension to content teaching. Next year I plan on using this toward my research class.

Teachers' Assessment of Microlab Training

Q 2. Do you feel more or less comfortable with hands-on lessons than before the training?

I was unable to work with microorganisms before this course.

I felt more comfortable now!

I have always done hands-on lessons. This training taught me how to use new materials and techniques. (feels "about the same")

I have had lots of experience with hands-on labs, so my comfort level has not changed but my knowledge base has increased. ("about the same")

I had difficulty handling live organisms but my ability improved with this experience.

I was already comfortable with hands-on lessons. This just reinforced my comfort level by providing more ideas of things that can enhance my lessons.

(more comfortable) specifically using equipment (organisms used…protists, etc)

more comfortable with these specific lessons.

Was already comfortable, but feel I have more items to utilize.

I was able to try out the procedures first and troubleshoot so that when I do it in my classes later, I'll know what to do /expect.

I had no confidence at all around microscope, and now I am in love!

I learned how to set up a video camera and I realized that my cell phone had more bacteria than the table top.

However, personally I enjoyed the class and would like to do some lessons in addition to our current science curriculum.

Q 3. Overall, how was the level of science content for you?

I don't think the level necessarily needs to be much more advanced, but I would have benefited if we had gone through the conceptual parts faster, leaving more time for more activities using the great materials.

Slightly above what I teach. I can still use the info/equip/tech

Great! engaging

The science content was good—but I was getting more in terms of technique than the content per se.

Learned and relearned a lot of things.

Q 7. When do you plan to borrow the Microlab kit?

Some time in the coming school year.

The 6th grade curriculum has changed. I believe we will study life science in the winter.

During Life Science session for grade 6 & 7; sometime in spring 2008.

Q 8 After the course, how competent do you feel about using the portable lab equipment?

I'm not sure yet how I'll feel once I have it, but I'm definitely going to try!

Q 10. Anything else we should know about the training?

Tara (Hawaiian Tara) was excellent. She was able to explain and break down how to use the Microlab, also explaining when we could apply each lab activity.

Tara is great! Extremely knowledgeable, enthusiastic, and (illegible). The time going out into the hall of sci. to fill out worksheets was not a useful to me as the time using the rentable science equipment and working with the microorganisms.

Excellent workshop. The presenters were very knowledgeable. Thank you.

Future training courses! I would like to take as many courses.

Training was very good. Repetition was very helpful. Great lessons and activities!

This was a very nice institute. It would have been more helpful to focus more on the different grade levels. Activities for: early childhood, elementary, middle, high school.

More hands-on acts in line w/ the NYC middle school curriculum. It can really enhance my teaching strategies. Thus more students will benefit from this endeavor.

I think we could have skipped the mold presentations because most of us had a lot of experience with presenting.

Thank you for keeping in mind the different experience levels and needs of the teachers in the training. For example, teachers of middle school will be teaching this information at a much more basic level. (if there is enough interest, perhaps you could offer MS and HS separately.)

I think it would be good if someone who has very little experience with the equipment had a little extra time to learn to use them.

Given the rental period, I only wonder how much of the cart I'll be able to use within the time available.

The staff was very supportive and informed.

Trainers are very knowledgeable and great personality.

Cut back on the number of trials we do—we ran out of time doing 3 trials of control, alcohol and caffeine on the daphnia. Less time making PowerPoints—can demo more lessons this way.

I enjoyed the investigative nature of the labs.

I liked how this was more open-ended.

I don't think it was necessary to have us complete the lab report/PowerPoint of the mold lab. Getting the idea of the concept of setting up an investigation would have been sufficient. Limit it for a discussion only.

Having teachers create PowerPoints/posters of the mold/dlom experiment was a bit pointless—just a simple discussion/conversation would have been enough. Also, the antibiotic lab didn't work, but that wasn't your fault.

I hope NIH will continue funding trainings like the Biotech and Microbio. Trainings are indeed helpful!

It was very engaging.

I have never had so much fun in a training session that met during my spring break. This was wonderful.

Great training. I enjoyed the ??

I learned a lot, the activities were well-planned, well-organized, and enjoyable for all ages!

Thanks for providing us with courteous professionals.

I wish I could offer some suggestions but everything is perfect (especially the instructors).

I liked all the hands-on activities especially the ones with living organisms. This will make my classes so much more exciting. I would have liked to learn how to use the flex cams with Windows based programs so I would not need to borrow the laptops.

Keep on offering more science hands-on activities.

more space might help for people to move around easier.

My colleagues were willing to help me because they were fascinated with gel electrophoresis technique and wanted to see this lesson in action. Therefore, they were more eager than the students to see this lesson in action, so they allow me to use the lab room all week to get the labs done, while visiting in their free period.

Our school is fortunate to enjoy a flexible schedule, and so we're able to make up a curriculum that makes best use of all resources available. However, the alignment of the kit with basic state standard contents (especially DNA structure, function and electrophoresis) mean that simply using the kit as specified satisfies mandated objectives.

At our school, the curriculum is actually very flexible. As long as the material is relevant and accessible, and secondly, we are preparing our students for the Regents, we can arrange curriculum however we want. That said, we did not use the kit for as many of the excellent activities in the activity book as we would have liked. Having the micropippetors and gel electrophoresis boxes allowed us to design activities that would be most relevant to the goals of our unit, which was to extract and manipulate human mitochondrial DNA.

I was able to use it in my genetics unit.

Thank goodness my laboratory specialist was able to make up all the agarose gels. I had a preparation period before and after my Lab periods.

I made sure to time my unit to the scheduled time we were to receive the kit. I used it during my unit on genetics and it allowed the students to utilize the gel electrophoresis lab procedure.

I used it in the genetics unit.

I used the bioterrorism lab after we spoke about threats to human health.

I did the best I could since I only had the kit for one week. Some classes I was able to run gels in traditional lab groups and for others I had to do demos due to lack of time. I also had to omit many of the lessons I could have done. Two weeks would have been awesome with the kit. I had the gels pre-made so that we didn't have to do that step.

I teach a non-Regents class so I have a bit more flexibility. It was nice to have several lessons to choose from though.

I prepared the students in advance with the content, and set aside two straight weeks which included a double session each week. I also counted the hours towards their New York state lab requirement. This was very helpful in getting some students who were delinquent in lab caught up!

Used in a genetics unit in one class, disease unit in another class. Directly applicable to necessary standards.

Gels were prepared in advance by myself and the lab specialist and stained by student volunteers at the end of the day. As for content, I taught the chemistry of DNA and then biotech, and am now spiraling the content and using the sickle cell case study to discuss principles of inheritance.

I found that preparing each experiment on my own time allowed me to execute each experiment in a timely manner. However, one week is not enough time to accomplish all the activities in the kit. We had a lot of fun and the students enjoyed each activity.

Appendix E. Teachers' Unsolicited Comments

The micropippetting class was a success. I also prepared a demo of the sickle cell and cancer gene detection and then showed the results to my classes. One outcome was a real spark in my students interest in lab investigation as a profession. My supervisor emailed me a "well-done" message the day she came in with us for the gel preparation. It was truly a positive experience and I thank you all at NY Hall of Science.

I really did enjoy using the Biotech kit. It was also nice not to have to worry about setting up the plates, other supplies, etc. Thanks again for all of your help.

[I] wanted to let you know how much J is enjoying the study of DNA. She speaks very highly of you and your passion for your work. Thanks for sparking J's interest in biology…

The kids asked me today when we were getting another kit from the Hall. I told them that I was doing the microbio training in May. They want another kit to come. They love it!

Thank you for taking time from your busy schedule to help us. The lab results were great and our understanding of restriction enzymes is now clear!

Appendix F. Evaluative Instruments

Study 1. Biotech Baseline Survey

BiotechLab Baseline Survey

1. School Data

To comply with the terms of our grant, the New York Hall of Science needs to assess the value of the professional development Institute and portable laboratory program. Please fill in this baseline data for our records. Thank you for your time and interest.

1. Your school (name):

2. Please check the category of your school (check all that apply):

- ☐ Public
- ☐ Independent
- ☐ Parochial
- ☐ Other (please specify)

3. Please list the names of the (non-regents) science courses you teach.

Middle School

High School

2. Regents Info

4. Please check the science regents course(s) that you teach:

- ☐ Chemistry
- ☐ Earth Science
- ☐ Living Environment
- ☐ Physics
- ☐ None

5. Of the students in your science regents classes, how many will take the examination this year?

- ☐ None
- ☐ 1-25%
- ☐ 26-50%
- ☐ 51-75%
- ☐ 76-99%
- ☐ ALL

6. What is the main reason the others do not take the exam? (If you answered None above, please write N/A.)

BiotechLab Baseline Survey

3. Professional Development/Skills

7. Highest level of education you have completed:

- ◯ Bachelor
- ◯ Masters
- ◯ Ph.D./Ed.D.

8. How many years have you been teaching?

9. Have you taken any professional development courses in the past five years?

◯ Yes ◯ No

10. If you answered yes to question 9, please list the professional development courses you have taken next to the corresponding year.

2006
2005
2004
2003
2002

11. What is the main reason you signed up for this training program?

4. Personal Information

12. Please rate your skill/knowledge level in the following areas:

	None	Minimal	Average	Above Average	Extremely Knowledgeable
DNA Structure and Function	◯	◯	◯	◯	◯
Punnet Squares	◯	◯	◯	◯	◯
Gel Electrophoresis	◯	◯	◯	◯	◯
Centrifuging	◯	◯	◯	◯	◯
Micropipetting	◯	◯	◯	◯	◯
Restriction Enzymes	◯	◯	◯	◯	◯
Gene Transformation	◯	◯	◯	◯	◯

* **13. Thank you for your time and interest in the BiotechLab Training Institute at the New York Hall of Science.**

Your Name:
Your e-mail:
Today's date:

Study 2. Biotech Training Daily Assessment

Date:

Question 1 – What is one new concept or skill you learned today?

Question 2 - Was there anything in today's workshop that was NOT useful to your teaching? Why?

Question 3 - Would you be interested in taking any of the investigations you learned today in to your classroom? If so, which ones?

Additional Comments

Study 3. Biotech Lab Training: Teachers' Evaluation

Our funder, the National Institutes of Health, needs to know how useful teachers find the BiotechLab training. Please take a few minutes to give us your honest assessment.

1. How useful was the BioTech Lab training for the course(s) you teach?

❑ Very useful

❑ Somewhat useful

❑ Not very useful

❑ Not at all useful

❑ Other, please specify:

2. How closely did the training meet your expectations?

❑ Better than I expected

❑ About what I expected

❑ I was disappointed

Please explain your answer: what did you expect and how did the training compare?

3. Overall, how was the level of the science content for you? Was it…

❑ Too Simple

❑ Too advanced

❑ About right

Comments:

4. Did the instructors explain the lab activities and related science clearly?

❑ Yes, always

❑ Not always

If you checked "not always," please be more specific. Constructive criticism will help us improve the training. (You don't have to sign your name.)

5. What else can we do to improve the training?

6. Now that you have completed the BioTech training, please rate your skill/knowledge level in the following areas:

	None	Minimal	Average	Above average	Extremely knowledgeable
DNA structure and function					
Punnet squares					
Gel electrophoresis					
Centrifuging					
Micropipetting					
Restriction enzymes					

7. When do you plan to borrow the BioTech kit to use in your classroom?

❑ Within the next 2 months

❑ In 2-4 months

❑ During summer school

❑ Next fall

❑ Other (please specify)

8. Briefly, how do you plan to use the BioTech kit in your teaching?

9. How helpful will it be to have a professional developer from the New York Hall of Science work with you and your class the first time you borrow the kit?

❑ Very helpful

❑ Somewhat helpful

❑ Not very helpful

❑ Not at all helpful

❑ Other (please specify)

10. Anything else we should know about the training?

Name (optional): _____

Study 4. Teachers' Assessment of Biotech Kit

BioTech Kit Assessment

1. School Information

The NY Hall of Science needs your feedback on the BioTech Kit you borrowed. Please take a few minutes to tell us about your experience with the kit in your classroom.

*** 1. Your school:**

2. School type:

◯ Public ◯ Independent ◯ Parochial

3. List the courses in which you used the BioTech Kit:

	Middle School	High School
Living Environment	☐	☐
AP Living Environment	☐	☐
Biology	☐	☐
AP Biology	☐	☐
Chemistry	☐	☐
AP Chemistry	☐	☐
General Science	☐	☐
Other	☐	☐

4. Number of sections for each course:

5. Number of students each section:

2. Lessons Used

BioTech Kit Assessment

6. Check the lessons you used and rate them on their level of difficulty for your classes.

	Too Advanced	Too Simple	About Right	N/A
1. Introduction to DNA	◯	◯	◯	◯
2. DNA Structure & Function: Replication & Protein Synthesis	◯	◯	◯	◯
3. What is Biotechnology? Debates, Dilemmas & Decisions	◯	◯	◯	◯
4. Delicious DNA: Isolating DNA from Fruits	◯	◯	◯	◯
5. Preparing a Gel for DNA Study	◯	◯	◯	◯
6. Mastering the Art of Micropipetting	◯	◯	◯	◯
7. Principles & Practice of Agarose Gel Electrophoresis	◯	◯	◯	◯
8. Restriction Enzymes: The "Molecular Scissors" of Biotechnology	◯	◯	◯	◯
9. In Search of the Sickle Cell Gene	◯	◯	◯	◯
10 Cancer Gene Detection	◯	◯	◯	◯
11. Bioterrorism Threat in NYC Train Systems	◯	◯	◯	◯
12. Cloning Glow Germs! Transformation of E. Coli with Fluorescent Jellyfish Proteins	◯	◯	◯	◯

7. Is there anything you can suggest to improve the kit?

3. Overall assessment

Overall, how would you assess your experience using the kit?

8. Was the kit a useful addtion to your curriculum?

◯ Yes, very useful ◯ Yes, somewhat useful ◯ No, not particularly useful ◯ No, not at all useful

9. Which specific concepts did the kit convey to your students? (list the top 5 below)

Specific concept 1:

Specific concept 2:

Specific concept 3:

Specific concept 4:

Specific concept 5:

BioTech Kit Assessment

10. Was the mobility of the kit and its flexibility helpful or not?

- ☐ Yes, very helpful
- ☐ Yes, somewhat helpful
- ☐ No, not particularly helpful
- ☐ No, not at all helpful
- ☐ Other (please specify)

11. Please describe how you were able to use the experiments within the relatively infexible school schedule and curriculum requirements.

12. Will you request use of the kit again?

◯ Yes, definitely ◯ Possibly ◯ No I won't

4. Personal Data

Columbia University will send your stipend check upon receipt of this evaluation.

*** 13. Your name:**

*** 14. Your email:**

Study 5. Microlab Baseline Survey

MicroLab Baseline Survey 1

1. School Data

To comply with the terms of our grant, the New York Hall of Science needs to assess the value of the professional development Institute and portable laboratory program. Please fill in this baseline data for our records. Thank you for your time and interest.

1. Your school (name):

2. Please check the category of your school:

- ◯ Public
- ◯ Independent
- ◯ Parochial
- ◯ Other (please specify)

3. What grade level(s) do you teach?

- ☐ Pre-K Elementary
- ☐ Middle School
- ☐ High School

4. Please list the names of the (non-regents) science courses you teach.

Middle School

High School

2. Regents Info

5. Please check the science regents course(s) that you teach:

- ☐ Chemistry
- ☐ Earth Science
- ☐ Living Environment/Biology
- ☐ Physics
- ☐ None

MicroLab Baseline Survey 1

6. Of the students in your science regents classes, how many will take the examination this year?

- [ ] None
- [ ] 1-25%
- [ ] 26-50%
- [ ] 51-75%
- [ ] 76-99%
- [ ] ALL

7. What is the main reason the others do not take the exam? (If you answered None above, please write N/A.)

3. Professional Development/Skills

8. Highest level of education you have completed:

- ◯ Bachelor
- ◯ Masters
- ◯ Ph.D./Ed.D.

9. How many years have you been teaching?

10. Have you taken any professional development courses in the past five years?

◯ Yes ◯ No

11. If you answered yes to question 9, please list the professional development courses you have taken next to the corresponding year.

2006
2005
2004
2003
2002

12. What is the main reason you signed up for this training program?

4. Personal Information

MicroLab Baseline Survey 1

13. Please rate your skill/knowledge level in these areas of equipment and programs:

	None	Minimal	Average	Above Average	Extremely Knowledgeable
Microscope	◯	◯	◯	◯	◯
Deep-well slides	◯	◯	◯	◯	◯
Videomicroscope	◯	◯	◯	◯	◯
Video camera	◯	◯	◯	◯	◯
Projector	◯	◯	◯	◯	◯
MacClade software	◯	◯	◯	◯	◯
PAUP (Phylogenic Analysis Using Parsimony) software	◯	◯	◯	◯	◯
Vernier Probeware (Logger Pro, Lab Pro Unit, CO2 Sensors)	◯	◯	◯	◯	◯
Clear One Flex Cam	◯	◯	◯	◯	◯
iMovie	◯	◯	◯	◯	◯
iPhoto	◯	◯	◯	◯	◯

14. Please rate your skills/knowledge using organisms:

	None	Minimal	Average	Above average	Extremely knowledgeable	Don't know
Live microogranism cultures	◯	◯	◯	◯	◯	◯
Yeast CO2 production	◯	◯	◯	◯	◯	◯
Chaos chaos amoeba	◯	◯	◯	◯	◯	◯
Daphnia magna	◯	◯	◯	◯	◯	◯
Plating bacteria with antibiotics	◯	◯	◯	◯	◯	◯

*** 15. Thank you for your time and interest in the BiotechLab Training Institute at the New York Hall of Science.**

Your Name: _____

Your e-mail: _____

Today's date: _____

Study 6. Microlab Training Daily Assessment

Question 1 – What is one new concept or skill you learned today?

Question 2 - Was there anything in today's workshop that was NOT useful to your teaching? Why?

Question 3 - Would you be interested in taking any of the investigations you learned today in to your classroom? If so, which ones?

Additional Comments

Study 7. MicroLab Training: Teachers' Evaluation

Our funder, the National Institutes of Health, needs to know how useful teachers find the MicroLab training. Please take a few minutes to give us your honest assessment.

1. How useful was the MicroLab training for the course(s) you teach?

❑ Very useful

❑ Somewhat useful

❑ Not very useful

❑ Not at all useful

❑ Other, please specify:

2. Do you feel more or less comfortable with hands-on lessons than before the training?

❑ Much more comfortable with hands-on lessons

❑ A little more comfortable with hands-on lessons

❑ I feel about the same as before the training regarding hands-on lessons

❑ I feel a little less comfortable with hands-on lessons

❑ I am much less comfortable with hands-on lessons

Please explain (optional):

3. Overall, how was the level of the science content for you? Was it…

❑ Too Simple

❑ Too advanced

❑ About right

Comments:

4. Did the instructors explain the lab activities and related science clearly?

❑ Yes, always

❑ Not always

If you checked "not always," please be more specific. Constructive criticism will help us improve the training.

6. Now that you have completed the MicroLab training, please rate your skill/knowledge level in the following areas:

	None	Minimal	Average	Above average	Extremely knowledgeable
Microscope					
Deep-well slides					
Videomicroscope					
Video camera					
Projector					
MacClade software					
PAUP (Phylogenic Analysis Using Parsimony)					
Vernier Probeware (Logger Pro, Lab Pro Unit, CO2 Sensors)					
Clear One Flex Cam					
IMovie					
iPhoto					

7. When do you plan to borrow the MicroLab kit to use in your classroom?

❑ Within the next 2 months

❑ In 2-4 months

❑ During summer school

❑ Next fall

❑ Other (please specify)

8. After the course, how competent do you feel about using the portable lab equipment?

❑ Very comfortable

❑ Somewhat comfortable

❑ Not very comfortable

❑ Not at all comfortable

9. How helpful will it be to have a professional developer from the New York Hall of Science work with you and your class the first time you borrow the kit?

❑ Very helpful

❑ Somewhat helpful

❑ Not very helpful

❑ Not at all helpful

❑ Other (please specify)

10. Anything else we should know about the training?

Your name: _____

Study 8. Teachers' Assessment of Microlab Kit

Microlab Kit Assessment

1. School Information

The NY Hall of Science needs your feedback on the Microlab Kit you borrowed. Please take a few minutes to tell us about your experience with the kit in your classroom.

*** 1. Your school:**

2. School type:

◯ Public ◯ Independent ◯ Parochial

3. List the courses in which you used the Microlab Kit:

	Middle School	High School
Living Environment	☐	☐
AP Living Environment	☐	☐
Biology	☐	☐
AP Biology	☐	☐
Chemistry	☐	☐
AP Chemistry	☐	☐
General Science	☐	☐
Other	☐	☐

4. Was the Microlab Kit in an Elementary School Class?

◯ Yes (K-2)

◯ Yes (3-5)

◯ No

5. Number of sections for each course:

6. Number of students each section:

2. Lessons Used

Microlab Kit Assessment

*** 7. Check the lessons you used and rate them on their level of difficulty for your classes.**

	Too Advanced	Too Simple	About Right	N/A
1. Basic light microscopy	◯	◯	◯	◯
2. What are magnification, resolution and field of view?	◯	◯	◯	◯
3. What is life?	◯	◯	◯	◯
4. Journey into microspace	◯	◯	◯	◯
5. Cell in a bag	◯	◯	◯	◯
6. How do we make sense of and organize the living world?	◯	◯	◯	◯
7. What are the best conditions for the land of DLOM to flourish?	◯	◯	◯	◯
8. How do environmental changes affect the metabolism of yeast and influence CO2 production?	◯	◯	◯	◯
9. How do induced environmental changes affect bacteria?	◯	◯	◯	◯
10 What are the effects of hypertonic, hypotonic and isotonic solutions on Chaos chaos?	◯	◯	◯	◯
11. How do environmental changes affect the heart rate of Daphnia magna?	◯	◯	◯	◯
12. How are aquatic microscopic invertebrates related to one another?	◯	◯	◯	◯

8. Is there anything you can suggest to improve the kit?

3. Overall assessment

Overall, how would you assess your experience using the Microlab kit?

*** 9. Was the Microlab kit a useful addtion to your curriculum?**

◯ Yes, very useful ◯ Yes, somewhat useful ◯ No, not particularly useful ◯ No, not at all useful

*** 10. Which specific concepts did the Microlab kit convey to your students? (list up to 5 below)**

Specific concept 1:

Specific concept 2:

Specific concept 3:

Specific concept 4:

Specific concept 5:

Microlab Kit Assessment

*** 11. Was the mobility of the kit and its flexibility helpful or not?**

- ☐ Yes, very helpful
- ☐ Yes, somewhat helpful
- ☐ No, not particularly helpful
- ☐ No, not at all helpful
- ☐ Other (please specify)

*** 12. Please describe how you were able to use the experiments within the relatively infexible school schedule and curriculum requirements.**

*** 13. Will you request use of the kit again?**

- ◯ Yes, definitely
- ◯ Possibly
- ◯ No I won't

4. Personal Data

Columbia University will send your stipend check upon receipt of this evaluation.

*** 14. Your name:**

*** 15. Your email:**

Study 9. Biotech and Microlab Kits: Final Thoughts

NY Hall of Science BioTech and MicroLab Kits: Final Thoughts

NYHoS Science Kits: Students' response

As the Columbia University/NY Hall of Science NIH grant period comes to an end, we would would like to share your thoughts about how your students responded to the kits with the grantor.

If you only used one of the kits, write N/A in the box concerning the other.

1. What activities in the BioTech kit were most engaging for students?

2. What activities in the MicroLab Kit were most engaging for students?

3. Was there anything in the BioTech Kit that was not successful?

4. Was there anything in the MicroLab Kit that was not successful?

5. Please tell us something that stands out in your memory regarding using the kits in class. It can be positive, negative, funny or serious.

*** 6. Please tell us who you are.**

Name:

School:

Email Address: