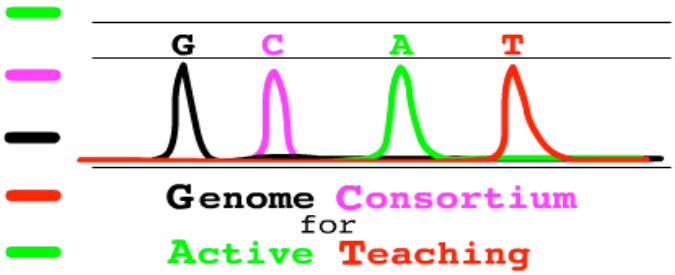

2009-2010 GCAT Assessment
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Students

Students that responded to some portion of the GCAT survey were separated into one of three groups: used GCAT materials, did not use GCAT materials (control), and don't know. Students who belonged to the 'don't know' group received this label because students with the same professor did not consistently identify with either of the two groups above (GCAT or control) and the faculty member failed to respond to the post- survey. Therefore this data was removed from further analysis. Displayed below is a table detailing the participation of student respondents to the pre- and post- GCAT surveys. The fourth column ("Both N") indicates the number of students in each group who completed both the pre- and post- surveys and who also took the surveys more than one week apart.

Group	Pre-test N	Post-Test N	Both N
GCAT	576	568	472
Control	62	35	30
Don't Know	177	19	16

I. Pre- GCAT Assessment

The following demographic information is representative of the 576 students that used GCAT materials and completed the pre- GCAT survey. Participating GCAT students reported attending 49 colleges and universities. The majority of the students are pursuing a degree in biology (72.2%), and an additional 12.0% are completing pre-medical coursework. The majority of the participants were seniors (64.2%), followed by juniors (24.7%). For 71.2% of students, the class was a requirement of their major. Basic demographic information is provided in the table below.*

Gender (%)			*School Year* (%)		
	Male	39.6		Freshman	0.0
	Female	59.7		Sophomore	6.4
				Junior	24.7
Race/Ethnicity (%)				Senior	64.2
	American Indian/Alaskan Native	0.5		Other	4.3
	Asian	10.8			
	Black/African American	2.8	*Academic Major* (%)		
	Caucasian/White	70.5		Biology	72.2
	Hispanic/Latino	7.3		Chemistry	9.2
	Multi Racial	1.0		Education	0.3
	Other	0.3		Math/Computer Sci.	0.7
				Physics	0.3
Overall GPA (%)				Pre-medicine	12.0
	3.50-4.00	45.3		Psychology	0.2
	3.00-3.49	39.2		Non-science	0.7
	2.50-2.99	13.2		Other	3.8
	2.00-2.49	1.7			
	1.50-1.99	0.2			

* Not every demographic item's percentages add up to 100% due to students who chose not to respond to some items or who selected multiple options on the same item.

II. Post- GCAT Assessment

GCAT Laboratory Experience

The following information is representative of the 568 students that used GCAT materials and completed the post- GCAT survey. After their GCAT semester, students indicated if they had been successful in performing the GCAT activities listed below. The activity in which students were most successful was scanning their microarray chips (83.3%). At least 50% of the students were able to complete each of the four tasks listed below.

GCAT Activity (%)	
Make your own probe	60.6
Able to get the chips scanned	83.3
Obtain useable data from the chips	65.5
Analyze your own data	66.6

Analysis Software

In the post- survey, the same 568 students indicated which software program they used to analyze microarray chip data. An overwhelming majority of the students (86.6%) indicated that they had used MAGIC Tool for data analysis.

Software Used (%)	
MAGIC Tool	86.6
GenePix	5.3
Scananalyze	4.4
JTreeView	3.0
GeneSpring	1.3
Other	2.7
N/A	4.4

GCAT Activity Effectiveness

The 568 GCAT students who participated in the post-survey also rated the effectiveness of each of the following activities on a 7-point scale where 1 = *not effective at all*, 4 = *moderately effective* and 7 = *highly effective*. Students who rated an activity "not applicable" were excluded from calculations of mean scores, which caused the sample size for each activity to be less than 568.

GCAT Activity	Mean	St. Dev.	N
Practicing data analysis before I began analyzing my own data	5.53	1.41	477
Isolating RNA or genomic DNA used to produce probe	5.66	1.28	489
Producing the fluorescently-labeled probe	5.51	1.38	449
Hybridizing the probe with the spotted DNA	5.56	1.38	493
Designing my own experiment	5.23	1.62	360
Analyzing data from public domain source	5.49	1.46	467
Reading papers that used DNA microarrays	5.56	1.46	492

Students assigned an average effectiveness value of 5.51 (*SD* = 0.10) to all of the GCAT activities. Mean scores on individual activities ranged from 5.23 to 5.66, which demonstrates that students did not judge any activity to be drastically more or less effective than others. Additionally, all of the average ratings are above 4.0 on the 7-point scale, indicating that students judged all of the activities to be more than moderately effective. All activities should remain in the GCAT curriculum.

Student Knowledge

Eleven knowledge questions were presented in identical forms on the pre- and post-GCAT surveys. Students were instructed to answer without the use of notes or friends, and questions presented hypothetical scenarios pertaining to gene expression and microarray

experimentation techniques. The following analysis only includes the responses of the 462 students who participated in both pre- and post- GCAT knowledge tests, and who also took the surveys more than one week apart. These 462 students represent 45 different classes. Correct response rates for each item, students' knowledge gains, and effect sizes are found in the table on the following page.

On the pre- survey knowledge test, almost all correct response rates for each question were below 50%. The mean number of test items that students got correct before GCAT was 3.65 (SD = 2.12). Item 5 was particularly difficult for student participants; only 4.9% of students answered this item correctly on the pre-program survey. There was improvement in knowledge scores after the GCAT program; the mean correct number across all the test items after GCAT was 5.38 (SD = 2.27). Correct responses for each item increased on average by 15.62%. Questions 1 and 4 showed particularly large gains of improvement, 37.3% and 30.9% respectively. Knowledge gain and final performance were lowest on item 5 (6.3% increase from pre-, 11.2% correct at post- assessment); subject matter for this question relates to gene expression ratios using a graph. Future GCAT faculty and students should devote more time to this area. Furthermore, fewer than half of the student participants were able to answer items 2, 3, 5, 6, and 9 correctly after the GCAT program, indicating other areas of microarray experimentation and gene expression where improvements could be made in student knowledge. A paired samples t-test indicates that statistically significant gains were observed from pre- to post- assessment regarding the number of correct answers to knowledge questions ($t(470) = 15.53$, $p < 0.001$, $d = 0.79$).

Question	Subject Matter	% Correct Before GCAT	% Correct After GCAT	% Increase	d
1	Microarray experimentation - RNA	31.6	68.9	37.3	0.81
2	Microarray experimentation	29.2	44.5	15.3	0.32
3	Microarray experimentation - DNA	32.4	41.3	8.9	0.19
4	Microarray experimentation - bacteria	44.1	75	30.9	0.67
5	Gene expression ratios using a graph	4.9	11.2	6.3	0.24
6	Gene expression - probability	19.1	23.9	4.8	0.12
7	Gene expression - gene clusters	35.6	51.7	16.1	0.33
8	Gene expression using DNA microarray	35.4	53.4	18	0.37
9	Gene expression in catabolic pathway	37.9	47.9	10	0.21
10	Gene expression using microarray data	43.2	58.3	15.1	0.31
11	Gene expression - microarray technique	51.7	60.8	9.1	0.19

*All differences were statistically significant.

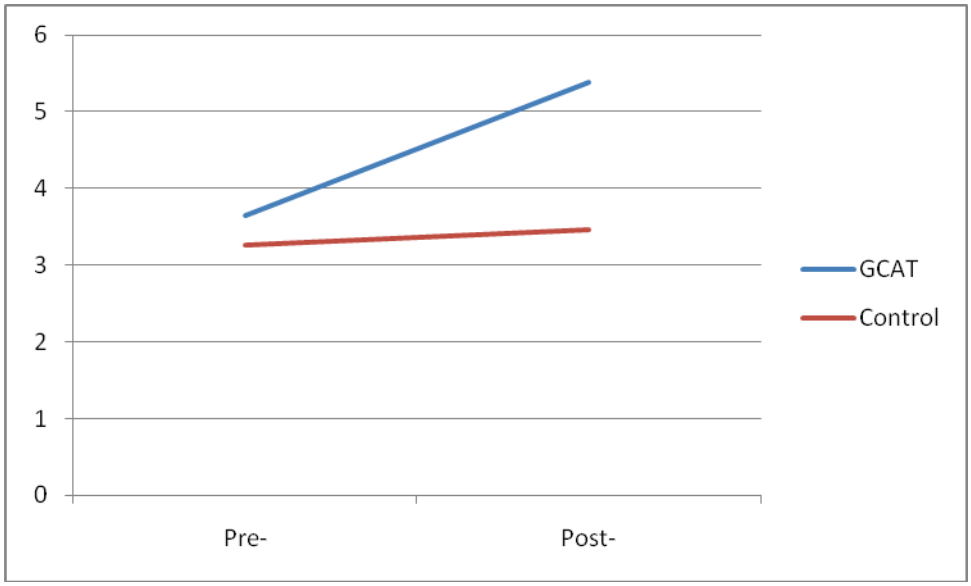
Control Group

In the control group, students (representing three different classes) completed both pre- and post- GCAT assessments. Lectures and reading assignments in the control classes were congruent with other classes who used GCAT materials, but the control class did not conduct laboratory experiments. Pre - and post- assessment scores on the knowledge test were examined in order to verify the effectiveness of the GCAT program. The following table compares the mean number of test items that students got correct on the pre- and post- assessments and the amount of change experienced between these two testing times.

Group	Pre-	Post-	Difference
GCAT	3.65	5.38	1.73
Control	3.27	3.47	0.20

The GCAT group had higher pre- and post- assessment means than the control group and improved approximately 8 times as much as the control group. In order to determine whether the GCAT group improved significantly more than the control group, a mixed 2x2 analysis of

variance was conducted, with time (pre- and post-) being the within-subjects factor and group (GCAT or control) as the between-subjects factor. The ANOVA showed a significant main effect of time, $F(499) = 17.785$, $p < .001$. This result indicates that there was significant change in knowledge test scores from pre- to post- assessment collapsing across group. A significant Time x Group interaction was also obtained, $F(499) = 11.197$, $p = 0.001$, $d = 0.72$. The rate of improvement from pre- to post- assessment significantly differed between the GCAT group and the control group. As displayed in the following graph, both groups improved over time, but the rate of improvement for the GCAT group was significantly greater than that of the control group over the course of the semester. Given the wide variety of activities that different classes may have engaged in and the fact that not all of the topics included in the knowledge test would be covered in individual classes, this result is extremely promising for the GCAT program.



Student Interests

Both the 472 GCAT students and the 30 control students rated how interested they were in genomics, life sciences, math/computer science, and research on a 10-point scale in the pre- and post- GCAT surveys, where 1 = *not interested at all* and 10 = *extremely interested.* Displayed below is a table with the average interest score for each area on the pre- and post- assessments.

	GCAT				Control		
	Pre	Post	Difference		Pre	Post	Difference
Genomics	7.39	7.32	-0.07		5.9	5.79	-0.11
Life Sciences	8.22	8.23	0.01		8.48	7.24	-1.24
Math/Computer Science	5.16	5.51	0.35		6.37	6.28	-0.09
Research	7.71	7.81	0.1		7.4	6.93	-0.47

Four 2x2 mixed ANOVAs were performed in order to identify any statistically significant differences in interest between the GCAT group and the control group. For genomics and math/computer science, the results showed no statistically significant difference between the GCAT group and the control group in terms of change in interest from pre- to post- assessment and showed no significant difference from pre- to post- collapsing across groups. Interest in life sciences showed both a significant interaction and a significant effect of time across groups. A significant Time x Group interaction of life sciences was obtained, $F(488) = 11.369$, $p = 0.001$, $d = 0.70$, demonstrating that while the control group's interest in life sciences decreased, the GCAT group remained about the same. The effect across time, $F(488) = 10.700$, $p = 0.001$, showed that on a whole the interest in life sciences decreased from pre- to post- test. Also, a significant interaction was obtained for interest in research, $F(493) = 5.402$, $p = 0.020$, $d = 0.24$, which indicates that the control group's rate of interest change was significantly less than that of the GCAT group.

Faculty

55 faculty members responded to some part of the post- GCAT survey, 52 of which reporting that they used GCAT materials and the remaining 3 being in the control group. 8 professors responded to the survey twice due to their participation in both semesters of the 2009-2010 school year. All professors who participated in the survey twice used GCAT both semesters. Therefore, there were 63 total responses to the post- GCAT survey, 60 of which used GCAT and the other 3 reported being in the control group.

Of the 63 classes using GCAT materials, 60.3% of the teachers reported having fewer than 10 students use microarrays. The average number of microarrays used was 10.88 (*SD* = 10.70). The average number of students who obtained useable data was 6.00 (*SD* = 7.69).

Selection of GCAT Activities, Time Spent on GCAT Activities, and Assessment of Students' Knowledge

Faculty members were asked to indicate which activities students participated in using GCAT materials and how many hours were allocated to each activity. They were also asked about the methods used to assess students' knowledge of genomic course material. Only a few teachers responded to questions in this section. In response to a question about which activities the students did while using GCAT materials, 2 teachers responded "analyze data from a public domain source", 1 responded "analyze their own data", and 2 chose "other activities". The teacher whose students analyzed their own data reported spending 6 hours on that activity, while the teachers whose students analyzed data from a public domain source reported spending 3 and 8 hours on that activity.

Teachers were also asked about the methods they used to assess students knowledge and understanding of genomics course material. Two teachers reported using a term paper or lab report. Two other teachers reported using informal feedback. One teacher used poster presentations and another teacher used tests.

Funding and Implementation

Of the 49 responses to the survey questions on funding, 38 reported receiving departmental funding in order to utilize GCAT materials. Six faculty members were supported by institutional funds, three reported receiving extramural funds, and the remaining two indicated that they received no funding to use the GCAT materials. Based on 48 responses, the average amount of funding received was $4,400.00 (*SD* = $14,644.77). Of the professors who responded to the implementation question, 75% of the professors did not feel that their implementation of GCAT materials was limited by computer resources (3 professors did not respond at all).

Professors' Evaluation of GCAT

After the GCAT program, professors rated their agreement with the following statements on a 5-point scale, where *1 = strongly disagree* and *5 = strongly agree*. Overall, the GCAT program was rated very favorably. Almost 70% of the faculty respondents strongly agreed (score of 5) with the statement "Overall, I had a positive experience using GCAT".

	Mean	St. Dev.
I would have access to microarray technology WITHOUT GCAT.	1.92	1.38
The online protocols available on the GCAT website were useful.	4.42	0.86
The GCAT-listserve (GCAT-L) was helpful.	4.23	0.82
The collection of other GCAT members as a support network was a significant factor in launching microarray technology on my campus.	4.07	1.13
Overall, I had a positive experience using GCAT.	4.62	0.83
I would use GCAT again in the future.	4.67	0.87

Additional Recommendations

There were more students this year who took both the pre- and post- surveys and who used GCAT than there were last year (472 this year and 355 last year). However, this year's GCAT program had much fewer control groups than last year. Last year, there were 183 control students who took both the pre- and post- test, but there were only 30 this year. Efforts to further increase the sample size of the control group will allow the comparison with the GCAT group to be made even more easily. In the GCAT group, there are also still many students who do not complete both pre- and post- surveys, meaning that many students' data could not be analyzed. This year, around 400 students' data could not be used because of the students' failure to complete both pre- and post- assessments or because they did not do so with an appropriate time period between the two (e.g. took the surveys less than one week apart). Therefore, continued efforts should be made to ensure participation by all students throughout the GCAT survey process.

Furthermore, a large amount of data (180 students) was discarded because students with the same professor were unable to consistently identify with one group (either GCAT or control) and their teacher failed to respond to the post faculty survey. Any gains we can make in improving faculty responses would also dramatically improve our sample size. Additionally,

faculty members should be reminded to instruct their students that the pre- assessment should be taken before the administration of the GCAT materials and that the post- assessment should be taken after the completion of the course. There were still some students that were completing both of the surveys within hours of each other and had to be removed from analysis.

Faculty Comments 2009-2010

Please provide any suggestions for future improvements in GCAT in the space provided.
This information is not for a class, but rather for one of my research students who used GCAT microarrays this past year. Thanks!
It's hard to think of ways to improve such an excellent program. The assessment had some difficult questions, though, in the sense that the answers don't allow clarification. For example, to hybridize probes, we used three separate sessions. I put the
We have only started using GCAT facilities this semester. It has been slow going, but so far, so good.
FYI, in this class (BIO311 Molecular Biology) I only used the wet lab simulation kit and the MediaBook animations and questions (which are excellent!).
A major limitation for us was not being able to have copies of MagicTool on the hard drives of the computers we were using. This made it difficult to use the software (it crashed often). If there was a way to run the software off a network drive, that w
No suggestion this round except another thank you for the workshop! Reminder that this semester I only did dry analyses of GCAT data with my students because of sickness. This took two lab periods and by the end of that time they were doing well with Ma
Having gene info files available for species other than yeast would make the data analysis experience more robust for the students.
We wasted quite a bit of time trying to figure out how the chick chip was organized. We used the student-friendly protocol available for the human arrays, but realized that the document describing the layout of the chick arrays was rather confusing. We
I love GCAT and appreciate how much it has changed my career and the enriching experience it has been for my students. I am now using microarrays in my research and have found collaborators using the GCAT listserve. Thanks, GCAT!
I enjoyed using the microarrays in class. The students enjoyed them as well but the experience was marred by two factors. The first was an error we made in RNA isolation that we can correct in the future. This reduced our signal and made the data only mar

The software continues to be a problem as it limits our ability to get useful data. Specifically we cannot normalize the data without the computer getting hung up. Second, our imaging data was poor once again. The RNA quality was good and this time we had
GCAT is great! The biggest challenge for my course was the availability of computers that could efficiently run the analysis for mouse arrays. last year we used yeast, and there was no problem there, I assume because the files were smaller. I'm looking
I wish someone would take the lead in getting GCAT into NextGen for mRNA analysis, at least in the dry lab context.
GCAT is great, but as people move to next gen sequencing to replace arrays it would be great if the program could evolve that way too.
Actually I have no suggestions for improvement. I think the list-serve is very effective in troubl shooting problems as they arise....the responses are always quick. I also appreciate the sharing of instructional materials through the list-serve and GC
The students in my 200-level genetics class made multiple errors in pipeting, other lab work, and in their haste to rush through the Magic Tools program. This occurred despite my being with them at all times, coaching and working with them to help avoid
The analysis still gives me lots of problems. My students don't like MAGIC at all. The gridding is cumbersome for large arrays and we couldn't save anything before the computer either froze or crashed. We also couldn't figure out a way to assess statistic
My only suggestion is to reconfigure the website, so that it is easier to navigate. Often it takes some digging to find what I'm looking for. I'll know that I have seen something at GCAT and will dig for it, but I know that colleagues have sometimes come
I love having MagicTool available, but I still had some issues getting the software to run properly. It was wonderful to be able to contact folks at Davidson, and with some of their suggestions, did eventually get the software to generate interpretable
GCAT has been a great organization, and a fantastic model for how one person's vision can be brought to fruition. I wish I would have been able to use the available resources better, but time/teaching load was the primary limiting factor.
No suggestions. It is great the way it is!
Everything worked out well. Thank you. This was a trial run. I plan to do more with more students next semester.
Thank you again for everything!
I really like magic tools ease of use but I wish magic tool at more options for statistical analysis of the data.
It was a great experience for all of my advanced Molec. Genetics students. I also worked with another faculty member who is a computer scientist and he helped teach the students how to use the MAGIC tool. It was great to engage in interdiscplenary teach

The microarrays that I used in 2009-10 were performed last summer. Because of this, the students did not perform either the pre nor post assessment for GCAT.
Some of the protocols online could be updated. There could be a 'helpful hints' section on the GCAT protocol page.