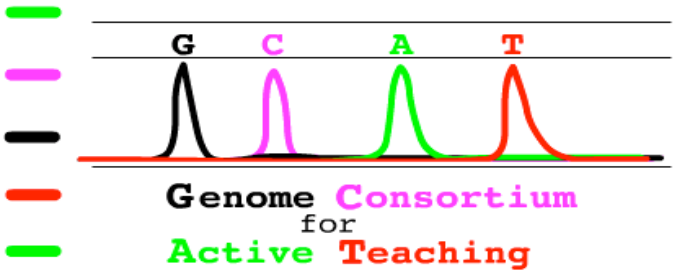

2009-2010 GCAT Assessment
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Students

872 students completed some portion of the GCAT assessment and 596 of those students completed both the pre- and the post- test. Of the students who completed both assessments, 543 took the assessments 7 or more days apart. Students that responded both the pre- and post-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, leaving 534 students remaining for analysis. For all analyses that follow, we only utilized data from individuals who completed both assessments. The table below shows the number of students in each group who completed both surveys.

GCAT	Control	Don't Know
492	42	9

I. Pre- GCAT Assessment

Participating GCAT students reported attending 40 colleges and universities. The majority of the students are pursuing a degree in biology (72.6%), and an additional 15.9% are completing pre-medical coursework. The majority of the participants were seniors (61.2%), followed by juniors (33.7%). For 75.4% of students, the class was a requirement of their major. Basic demographic information is provided in the table below.*

Gender (%)		*School Year* (%)	
Male	38.2	Freshman	0.0
Female	61.8	Sophomore	2.2
		Junior	33.7
Race/Ethnicity (%)		Senior	61.2
American Indian/Alaskan Native	3.0	Other	2.8
Asian	21.5		
Black/African American	2.6	*Academic Major* (%)	
Caucasian/White	58.5	Biology	72.6
Hispanic/Latino	10.0	Chemistry	8.7
Multi Racial	4.1	Psychology	0.4
Other	5.3	Math/Computer Sci.	0.6
		Pre-medicine	15.9
Overall GPA (%)		Other	1.4
3.50-4.00	41.9		
3.00-3.49	37.2		
2.50-2.99	16.5		
2.00-2.49	3.5		
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

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 (81.9%). At least 50% of the students were able to complete each of the four tasks listed below.

GCAT Activity (%)	
Make your own probe	58.3
Able to get the chips scanned	81.9
Obtain useable data from the chips	64.0
Analyze your own data	71.7

Analysis Software

In the post- survey, the 447 students indicated which software program they used to analyze microarray chip data and 45 did not respond to the question. An overwhelming majority of the students (85.8%) indicated that they had used MAGIC Tool for data analysis.

Software Used (%)	
MAGIC Tool	85.8
GenePix	4.7
Scananalyze	7.7
JTreeView	0.6
GeneSpring	0.0
Other	3.0
N/A	0.6
No response	9.1

*Some students choose more than one response.

GCAT Activity Effectiveness

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 492.

GCAT Activity	Mean	St. Dev.	N
Practicing data analysis before I began analyzing my own data	5.57	1.49	379
Isolating RNA or genomic DNA used to produce probe	5.62	1.35	408
Producing the fluorescently-labeled probe	5.56	1.37	380
Hybridizing the probe with the spotted DNA	5.63	1.36	422
Designing my own experiment	5.28	1.65	311
Analyzing data from public domain source	5.52	1.37	378
Reading papers that used DNA microarrays	5.34	1.58	390

Students assigned an average effectiveness value of 5.53 (*SD* = 1.15) to all of the GCAT activities. Mean scores on individual activities ranged from 5.28 to 5.63, 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 492 students who participated in both pre- and post- GCAT knowledge tests, and who also took the surveys more than one week apart. These 492 students represent 37 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, all correct response rates for each question were below or near 50%. The mean number of test items that students got correct before GCAT was 4.15 (SD = 2.28) out of 11 items. Item 5 was particularly difficult for student participants; only 6.3% 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 5.35 (SD = 2.53). Correct responses for each item increased on average by 10.98%. Questions 1 and 4 showed particularly large gains of improvement, 31.50% and 27.24% respectively. Knowledge gain was lowest on items 11 (2.64% increase) and 3 (3.25% increase). Questions 3 dealt with designing a negative control spot for a DNA microarray and question 11 dealt with gene expression and experiments to determine treatment. Future GCAT faculty and students should devote more time to these areas. Furthermore, fewer than half of the student participants were able to answer items 2, 3, 5, 6, 8, and 9 correctly after the GCAT program, indicating the 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 on the entire set of knowledge questions, $t(491) = 10.49$, $p < 0.001$, $d = 0.50$.

Question	Subject Matter	% Correct Before GCAT	% Correct After GCAT	% Increase	d
1	Microarray experimentation - RNA	36.79	68.29	31.50	0.66
2	Microarray experimentation	37.60	48.37	10.77	0.22
3	Microarray experimentation - DNA	39.84	43.09	3.25	0.07
4	Microarray experimentation - bacteria	43.50	70.73	27.24	0.57
5	Gene expression ratios using a graph	6.30	13.41	7.11	0.24
6	Gene expression - probability	19.92	26.02	6.10	0.15
7	Gene expression - gene clusters	40.24	56.10	15.86	0.32
8	Gene expression using DNA microarray	44.31	49.39	5.08	0.10
9	Gene expression in catabolic pathway	40.04	46.54	6.50	0.13
10	Gene expression using microarray data	50.20	54.88	4.67	0.09
11	Gene expression - microarray technique	55.89	58.54	2.64	0.05

*All differences were statistically significant except questions 3, 8, 10, and 11.

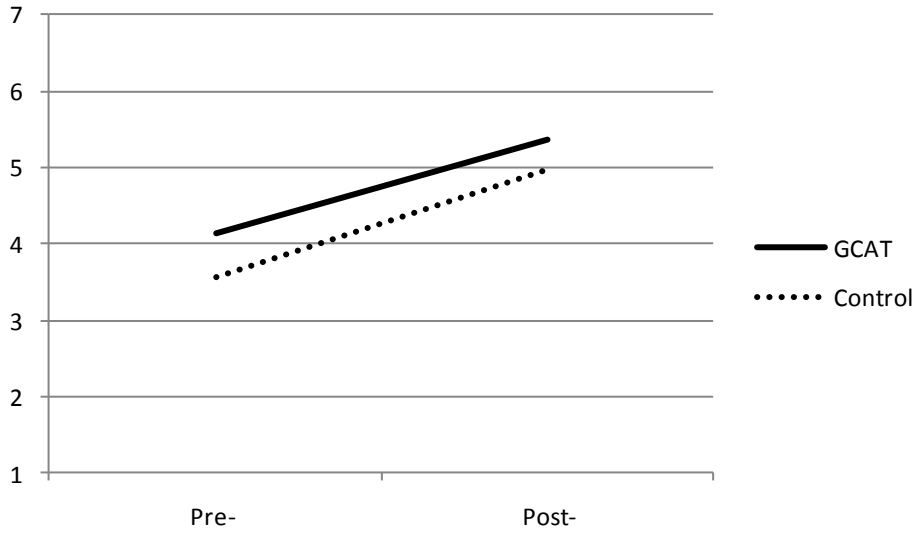
Control Group

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	4.15	5.35	1.20
Control	3.57	4.98	1.41

Unlike previous years, students in these three control classes displayed a similar amount of improvement when compared to the GCAT students (see figure below). A mixed 2x2 analysis of variance, with time (pre- and post-) being the within-subjects factor and group (GCAT or

control) as the between-subjects factor, confirmed that the two groups did not change at a different rate over time, $F(1,532) = .227$, $p = 0.634$, d = 0.09.



Because these results were inconsistent with prior years, we attempted to identify why control students showed similar improvement to GCAT students. One potential partial explanation is that one of the three control classes was taught by Dr. Malcolm Campbell who created the knowledge test. His familiarity with the knowledge test may have inadvertently affected his students' performance as the students in this class improved almost 3 points on average from pre to post assessment. If this control class was removed from the analysis, the GCAT students displayed about 50% more improvement on knowledge scores than the remaining control students, though this difference in improvement was still not statistically significant.

Student Interests

Both the GCAT students and the 42 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	7.41	0.02		7.38	7.49	0.11
Life Sciences	8.21	8.08	-0.13		7.95	8.22	0.27
Math/Computer Science	5.27	5.60	0.33		5.36	6.02	0.67
Research	7.89	7.72	-0.17		7.33	7.29	-0.04

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, research, and life sciences, 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 math/computer science showed a significant effect of time across groups, $F(1,502) = 9.04$, $p = 0.003$, d = 0.14, but not a significant interaction, $F(1,502) = 0.748$, $p = 0.38$, d = 0.11. This shows that across groups, interest in math and computer sciences increased modestly over the course of the semester, but the increase was similar for both the control and the GCAT group. This result is consistent with prior assessments that have tended to show interest gains only in the math/computer science area. One likely explanation for this is that GCAT tends to be part of upper-level classes so initial interest in genomics and the life sciences is usually higher than interest in math and computer science. Thus, there is more potential to improve in this area after exposure.

Faculty

Thirty-three faculty members responded to some part of the post- GCAT survey, 28 of which reporting that they used GCAT materials and the remaining 5 being in the control group (however we did not get student data from all of these classes). Of the 28 classes using GCAT materials, 32.1% of the teachers reported having fewer than 10 students use microarrays. The average number of microarrays used was 7.43 (*SD* = 3.40). The average number of students who obtained useable data was 8.64 (*SD* = 5.22).

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. Frequencies and hours per week spent on each activity are shown in the table below.

Activity	# Teachers	Hours Mean	Hours St. Dev.
Isolate total RNA or mRNA	25	3.08	0.76
Make cDNA probes	22	3.27	1.08
Make total genomic DNA probes	0		
Hybridize probes to microarray	28	4.14	1.98
Validate the quality of your RNA	22	2.10	0.96
Analyze their own data	23	6.96	3.46
Analyze data from public domain source	10	3.60	2.27
Design their own experiment	9	3.67	2.55
'Other' activities	11	4.55	3.45

Teachers were also asked about the methods they used to assess students' knowledge and understanding of genomics course material. A table showing the frequency of each type of assessment can be found below.

Assessment Type	Frequency
Test	8
Term paper/Lab report	19
Poster presentation	4
Oral presentation	10
Manuscript for publication	0
Course evaluation	10
Informal feedback	18
Pre/post survey	1
Class discussion	1
Post-laboratory "Roundtable Discussions"	1
Lab notebook	1
Essays	1

Funding and Implementation

Of the 21 responses to the survey questions on funding, 17 reported receiving departmental funding in order to utilize GCAT materials, 2 faculty members were supported by institutional funds, and the remaining 2 indicated that they received no funding to use the GCAT materials. The average amount of funding received was $1,753.85 (*SD* = $1,308.42). The vast majority of professors using GCAT (75%) did not feel that their implementation of GCAT materials was limited by computer resources.

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. Over half of the faculty respondents strongly agreed (score of 5) with the statement "Overall, I had a positive experience using GCAT".

	Mean	St. Dev.
The online protocols available on the GCAT website were useful.	4.58	0.76
The GCAT-listserve (GCAT-L) was helpful.	4.15	0.86
The collection of other GCAT members as a support network was a significant factor in launching microarray technology on my campus.	3.74	1.20
Overall, I had a positive experience using GCAT.	4.57	0.74
I would use GCAT again in the future.	4.67	0.55

Additional Recommendations

This year, 492 GCAT students took both the pre- and the post- test, but only 42 controls took both tests. 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, 329 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.

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. GCAT Students came from 37 different classes indicating that about one-third of the faculty failed to complete the faculty assessment.

Faculty Comments 2010-2011

Please provide any suggestions for future improvements in GCAT.
A peroidic call for updated protocols. GCAT could make contact with supppliers of labeling kits and request deeper discounts. The cost of the fluorescent labeling kits keeps increasing.
While only 2 of my groups got useable data, it was not reflective of their effort or the GCAT materials - FedEx managed to break the other 4 arrays which probably contained useable data.
More information/training on advanced data analysis (clustering, etc.) would be helpful.
The GCAT website is a bit of a mess. It needs to be cleaned up and reorganized to make it more easily usable. It can be very difficult to find material you are looking for. However, on-line tools, especially Perelli animation, are among the best out there. The MagicTool and other supporting materials are excellent and very helpful to students. It would be great if MagicTool were more stable and intuitively designed. It does a great job once expression files are built, but is very unstable across different CPU's even those that equivalent processors and OS's. This is immensely frustrating to students and very time-consuming. Nonetheless, I know of nothing else that provides such a great tool for allowing students to intimately interact with their microarray data-- as a teaching tool, there are important aspects of the design.
I wish it was doing NextGen sequencing.
From the website I see that plant arrays are pretty limited in numbers. I hope that in the future plant arrays will stay available.
Can't think of anything. I knew what and where to get the materials I needed and how to use them, especially with the experience of the workshop. It would have been much harder without the workshop.
No improvements necessary--excellent resource.