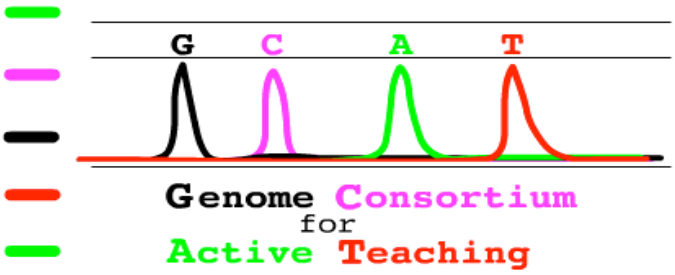

2007-2008 GCAT Assessment
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Students

Students that responded to some portion of the GCAT survey were separated into one of four groups: received GCAT materials, did not receive GCAT materials (control), don't know, and Marshall. Students that were selected 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 the control) and faculty failed to respond to the post faculty survey. Therefore these data were removed from further analysis. The Marshall group is a class taught by Dr. Marshall and was also held out of analysis because of an email exchange with Dr. Campbell. Listed below is a table detailing the participation of student respondents to the pre- and post-GCAT surveys. Keep in mind that many students only completed one of the knowledge based tests.

		N	
Group		pre-test	post-test
GCAT		510	394
Control		88	61
Don't know		316	106
Marshall		34	28

Demographic information

The demographic information reported uses responses from only those students that received GCAT materials and completed the pre-assessment; this information is listed below for the 510 students who completed the 2007-2008 pre-GCAT survey. Participating GCAT students reported attending 43 colleges and universities, the majority of whom are pursuing a degree in biology (76.1%); and an additional 31.0% are completing pre-medical coursework. The majority of the participants were seniors (43.4%), and 75.2% were upperclassmen. Students also reported whether the course using the GCAT materials was required for their academic major; for 34.6% of the students the class was not a requirement.

Academic Major (%)		*Course required for students' academic major?* (%)	
Biology	76.1	Yes	65.4
Pre-medicine	31.0	No	34.6
Education	0.8		
Chemistry	12.7	*School year* (%)	
Math/Computer Science	2.2		
Physics	0.4	Freshman	6.7
Non-science	2.7	Sophomore	11.4
		Junior	31.8
Race/ethnicity (%)		Senior	43.4
		Other	6.7
White/Caucasian	68.2		
Black/African American	3.5	*Gender* (%)	
Hispanic/Latino	6.5		
Asian American	10.4	Male	39.5
Multi-Racial	3.3	Female	60.5
Other	10.6		

Graduate education intentions

The following table outlines students' plans for continuing education after undergraduate school. The most popular degrees anticipated by GCAT participants were related to Medicine (57.3%), and Biology: Cell, Molecular, Genetics, Biochemistry (32.2%). Some students were unsure (8.8%), and another 3.3% reported no intentions to pursue an additional degree after undergraduate school.

Graduate education intentions (%)			
Medicine	57.3	Education	4.7
Chemistry	3.3	Law	1.8
Physics	0.8	Non-science	0.0
Math/Computer Science	0.4	Don't know	8.8
Biology: Behavior, Ecology of Field Biology	8.2	None	3.3
Biology: Cell, Molecular, Genetics, Biochemistry	32.2		

Prior research experience

Prior to the GCAT program, almost all students had some type of research experience (91.8%). The majority of students had introductory laboratory experience (83.3%), however 8.2% had no prior form of research experience. Students' self-reported laboratory experience is listed below.

Prior research experience (%)			
Introductory labs	83.3	Summer research	25.5
Upper level labs	24.3	None	8.2
Independent research	20.6		
Thesis project	10.0		

Completed coursework

Students reported which courses they had completed from the list below. The most common course was introductory biology (91.6%). Calculus (77.5%), Organic chemistry (73.1%), and Genetics (57.8%) were also relatively popular among participants. Few students had taken Genomics (6.1%) or Bioinformatics (7.1%) classes.

Courses completed (%)			
Introductory biology	91.6	Statistics	47.6
Genetics	57.8	Physics	55.7
Microbiology	36.5	Molecular biology/genetics	31.6
Immunology	15.9	Cell biology	46.5
Inorganic chemistry	47.1	Biochemistry	35.7
Organic chemistry	73.1	Genomics	6.1
Developmental biology	9.4	Bioinformatics	7.1
Neuroscience	8.8	Probability	10.0
Calculus	77.5	None of the above	3.5

Students' GCAT laboratory experience

Only students that completed the post- GCAT survey are included in the following post-GCAT analysis. After their GCAT semester, students indicated whether they were successful in performing the GCAT activities listed below. The activity in which students were most successful was scanning their microarray chips (78.2%). With the exception of making their own probe (45.1%), the majority of students were able to do each of the four tasks listed below.

Task	**% of students**
Make their own probe	45.1
Able to get the chips scanned	78.2
Obtained useable data	59.6
Able to analyze his or her own data	65.0

Analysis software

After the semester, students that received GCAT materials indicated which software program they used to analyze microarray chip data. MAGICTool was the overwhelmingly popular choice with 70.9% of the students using this software to analyze data.

MAGICTool	70.9 %
GenePic	7.6
Scananalyze	2.1
JTreeView	0.3
GeneSpring	0.6
Other	2.1
Not applicable	16.2

Student Attitudes

GCAT students 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.

GCAT activity	M	SD	N
Practicing data analysis before I began analyzing my own data	5.17	1.36	293
Isolating RNA or genomic DNA to produce probe	5.16	1.32	273
Producing the fluorescently-labeled probe	5.12	1.26	264
Hybridizing the probe with the spotted DNA	5.09	1.33	290
Designing my own experiment	4.88	1.54	205
Analyzing data from public domain source	5.20	1.29	274
Reading papers that used DNA microarrays	5.13	1.52	311

The average effectiveness value students assigned to all of these activities on the 7-point scale was 5.12, and mean scores on individual activities ranged from 4.88 to 5.20; on average, 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 effective, and these activities should continue to be included in the GCAT curriculum.

Student knowledge

Eleven knowledge questions were presented in identical forms on the two surveys, and a total of 327 students responded to both sets of questions. 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. Correct response rates for each question were below 50%. On average, students were the least knowledgeable about gene expression frequency and microarray experimentation with RNA at the outset of the GCAT program. The mean correct number across all the test items before GCAT was 3.2. Item 5 was particularly difficult for student participants; only 5.0% of students answered this item correctly on the pre-program survey. Correct response rates for each item and students' knowledge gains are found in the table on the following page.

There was improvement in knowledge scores after the GCAT program; the mean correct number across all the test items after GCAT was 5.1. Correct responses for each item increased on average by 18.4%. Questions 1, 4, and 7 showed particularly large gains of improvement: 38.4%, 29.1%, and 29.0%, respectively. Knowledge gains and final performance were lowest on items 5 (13.8% correct) and 6 (23.9% correct); subject matter for these two questions relates to gene expression ratios and probability. Future GCAT faculty and students should devote more time to gene expression and probability. Furthermore, fewer than half of the student participants were able to answer items 2, 3, 8, and 9 correctly after the GCAT program, which pertain to microarray experimentation methods and gene expression. Although dependent samples t-tests indicate that statistically significant gains were observed from pre- to post-evaluation regarding these questions, there is still considerable room for additional improvement. It is recommended that professors emphasize a wide range of microarray techniques in future GCAT programs.

Question	Subject matter	% correct *before* GCAT	% correct *after* GCAT	% increase
1	Microarray experimentation- RNA	26.7	65.1	38.4
2	Microarray experimentation	30.2	44.4	14.2
3	Microarray experimentation- DNA	30.8	47.2	16.4
4	Microarray experimentation- bacteria	36.0	65.1	29.1
5	Gene expression ratios using a graph	5.0	13.8	8.8
6	Gene expression- probability	17.3	23.9	6.6
7	Gene expression- gene clusters	29.8	58.8	29.0
8	Gene expression using DNA microarray	30.0	47.8	17.8
9	Gene expression in catabolic pathway	33.6	48.1	14.5
10	Gene expression using microarray data	36.9	54.3	17.4
11	Gene expression- microarray technique	48.9	64.0	15.1

Control group

Six control classes completed at least one part of the GCAT survey (pre-assessment, post-assessment, or both), totaling 149 students. Of those students, only 58 students completed both the pre- and post- 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.

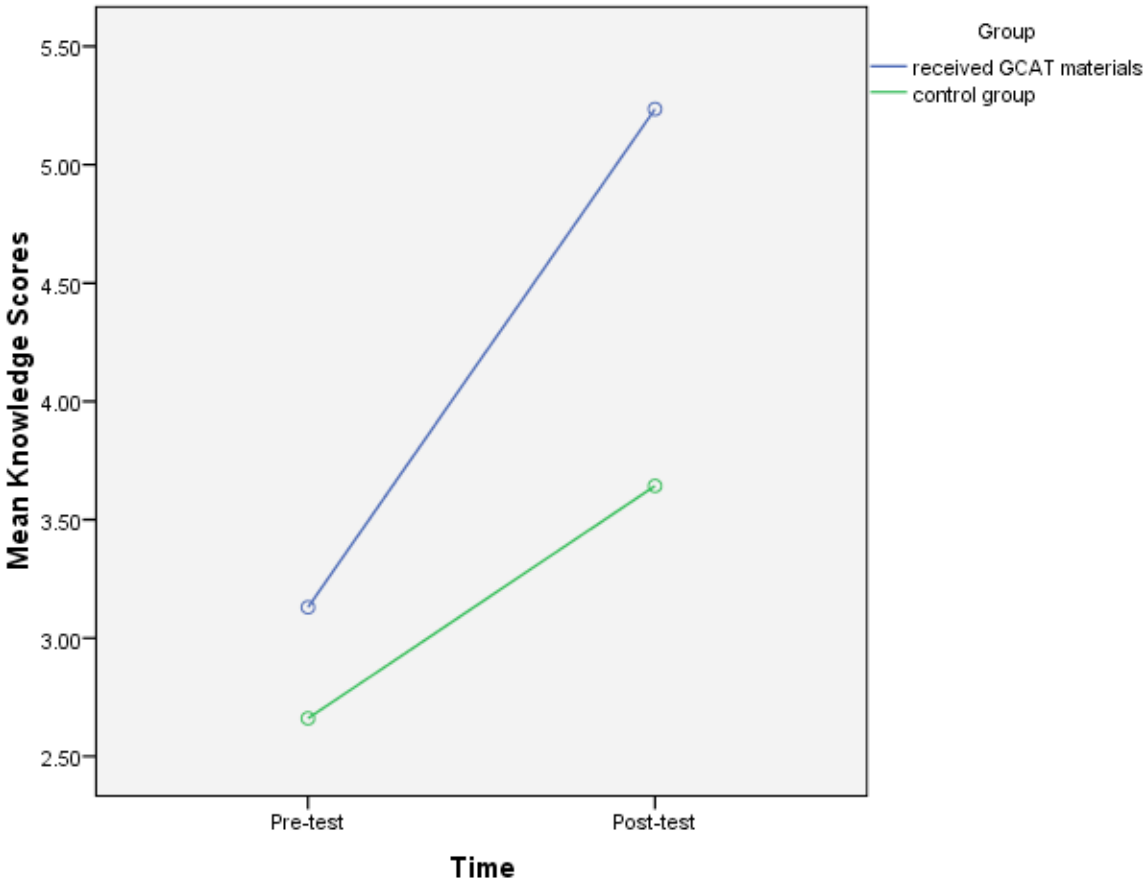
Pre-Post Changes

Pre - and post- evaluation scores were examined in order to verify the effectiveness of the GCAT program. The following table compares the means representing how many question items were correct at the various evaluation times and the amount of change experienced during these two testing times.

	Pre	Post	Difference
GCAT	3.23	5.26	2.03
Control	2.61	3.77	1.16

The GCAT group improved approximately twice as much as the control group. In order to determine whether this difference is statistically significant a mixed 2X2 analysis of variance was conducted, with

time being the within subjects factor and group (either receiving GCAT materials or control) as the between subjects factor. The ANOVA indicated significant main effects for both time $F(1, 398) = 17.46$, $p < .01$, and group $F(2, 398) = 11.39$, $p < .01$. A significant Time x Group interaction was also obtained $F(2, 398) = 7.127$, $p < .01$, though this was a weak effect (Eta-squared = .035). Nevertheless, given the wide variety of activities different classes may have engaged in and the fact that not all of the topics covered by the knowledge test would be covered in individual classes, this result is promising. This suggests that students who received the GCAT materials showed significantly more improvement over the course of the semester than the control group, who did not receive the GCAT materials.



Student attitudes

GCAT and control students rated how interested they were in the following areas on a 10-point scale on the pre- and post-GCAT surveys where 1 = *not interested at all* and 10 = *extremely interested.* At pre-survey evaluation the control students expressed more interest than the GCAT students in almost all assessed areas. However, at post-survey evaluation, overall, control students reported a loss of interest while the GCAT students expressed an increased amount of interest in these same evaluated areas. Although there was a difference, this magnitude of change was small relative to the variability among students and was not statistically significant.

	Control Students			GCAT Sudents		
	Pre	Post	Difference	Pre	Post	Difference
Genomic	6.24	5.81	-0.43	6.14	6.49	0.35
Life Sciences	7.70	7.75	0.05	7.48	7.84	0.36
Math/Computer Science	4.84	4.61	-0.23	4.71	4.83	0.12
Research	6.78	6.76	-0.02	7.24	7.34	0.10

Faculty

Students identified 45 professors who supervised their use of GCAT materials however only 35 faculty members completed the faculty survey at the end of the program. One faculty member responded to the survey twice because GCAT materials were used in both semesters of the 2007-2008 school year. More than half of the responding faculty reported having fewer than 10 students. Only 13.8% of the faculty reported having a class larger than 20. The average number of chips per student was 1.83. The percentage of students who got useable data was 64%.

Selection of GCAT activities

Professors reported which of the following activities were performed with GCAT materials in laboratory sessions. Percentages of professors who had their students perform each activity are reported in the table below. Hybridizing probes to microarray (87.0%) was the most popular among faculty,

while no faculty report to have made students make total genomic DNA probes. 95.7% of the professors reported performing at least three of the GCAT activities during the semester.

GCAT activity	% of professors who had students perform each GCAT activity
Isolate total RNA or mRNA	82.6
Make cDNA probes	82.6
Make total genomic DNA probes	0.0
Hybridize probes to a microarray	87.0
Validate the quality of your RNA	82.6
Analyze their own data	78.3
Analyze data from a public domain source	21.7
Design their own experiment	42.3

Relationship between time spent on GCAT activities and student knowledge gains

The increase in number of questions answered correctly from pre- to post-program surveys was computed for each student and averaged for each instructor (means were separated by semester when professors participated in GCAT during two consecutive semesters, however for the one professor that did meet this criteria his/her students didn't complete both the pre- and post- knowledge test). The correlation between the total number of hours spent on GCAT activities, as reported by faculty participants, and the average knowledge gain among their students was not significant ($r = .13$, $p = .63$, $N = 16$).

Faculty participants were asked how many hours they spent on each of the seven GCAT activities. These values were summed to yield a total GCAT time score for each professor. Time scores were quite varied, and it is likely that several are inaccurate. Most scores fell in the range of 15-30 hours for GCAT activities, however some professors report values as low as 5 hours, while others report as high as 130 hours. It is likely that they were doing more than one GCAT activity at a time throughout the semester, and this would make the sum of hours they reported very large. Since a number of students did not respond to the post-GCAT survey, sample sizes for knowledge gain scores for some professors' students were extremely small. A number of the faculty also did not respond to the number of hours spent on each GCAT activity thus contributing to a limited sample size.

Relationship between number of GCAT activities completed and student knowledge gains

Student post-assessment scores were averaged for each professor to compute a class average post-assessment score. This score was then correlated with the number of GCAT activities completed by each class, as reported by the faculty assessment. The number of GCAT activities completed was used because of the wide range in faculty reported hours spent on GCAT activities. This correlation was not significant ($r = .14$, $p = .57$, $N = 20$). Again, a number of faculty members did not respond to the number of GCAT activities completed.

Assessing students' knowledge

Professors were asked how they measured students' performance in the course in which they used GCAT materials. The most common assessment tool used by GCAT professors was term papers/lab reports (82.6%) and informal feedback (60.9%). As seen in the adjacent table, other methods were used frequently such as tests (47.8%) and oral presentations (47.8%). The least popular way that faculty assessed students was through preparation of a manuscript for publication (4.3%). Two professors reported "other" techniques. In the "please explain" text box next to this option, the professors added honor's thesis and written protocol as other means used to assess students.

Assessment method	% of professors who used each assessment method
Test	47.8
Term paper/lab report	82.6
Poster presentation	17.4
Oral presentation	47.8
Manuscript for publication	4.3
Course evaluation	39.1
Informal feedback	60.9

Funding and implementation

Funding that faculty received to utilize GCAT resources came from a variety of sources, but professors were supported most often with departmental funds (86.4%). 4.5% of professors indicated that they received no funding for using the materials provided by GCAT. Most professors (77.3%) did not feel that their implementation of GCAT materials was limited by computer resources.

Funding source	% professors receiving this type of funding
Departmental	86.4
Institutional	36.4
Extramural	18.2
None	4.5

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*. Most of the faculty responded that they would not have access to microarray technology without GCAT, and they also reported a positive overall GCAT experience. Faculty participants generally agreed that the online protocols and Listserve were helpful; future GCAT programs should retain these online features.

	M	SD
I would have access to microarray technology without GCAT	1.95	1.36
The online protocols available on the GCAT website were useful.	4.36	0.95
The GCAT-Listserve was helpful.	4.27	0.83
The collection of other GCAT members as a support network was a significant factor in launching microarray technology on my campus.	4.09	1.07
Overall, I had a positive experience using GCAT.	4.73	0.45

Additional recommendations

As always, one of the main problems continues to be the lack of participation in both the pre- and post- assessments by all students. While the dramatic decrease in the number of GCAT students who participated is limiting, the effect that this decreased participation has on the control group is even more significant due to the smaller sample size at the outset, which makes comparisons of the GCAT and the control group even more difficult. Therefore continued efforts should be made to ensure participation by all students throughout the GCAT survey process. We are making strides in including more control classes as part of the GCAT assessment, however a larger sample size for these control groups would be helpful in future evaluations. It is recommended that GCAT administrators continue to encourage faculty participation as controls in the assessments. Furthermore, a large amount of data was discarded because students with the same professor were unable to consistently identify with one group (either GCAT or control) and faculty 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, but these students were removed. Finally, we may want to brainstorm ideas about how to better identify control classes and also how to probe faculty regarding the actual activities control classes are engaged in.