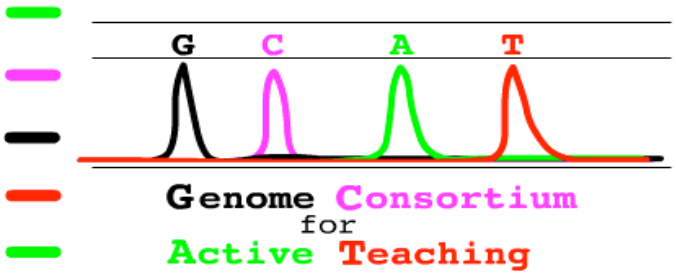

2006-2007 GCAT Assessment
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Students

Demographic information

517 students responded to at least one of the two program assessments, and 292 completed both surveys; demographic information is listed below for the 517 students who completed the 2006-2007 pre-GCAT survey. 39 colleges and universities were reported by participating students, the majority of whom are pursuing a degree in biology (77.6%); and an additional 31.6% are completing pre-medical coursework. The majority of the participants were seniors (63.5%), and 88.2% were upperclassmen. Students also reported whether the course using the GCAT materials was required for their academic major; for 42.3% of the students the class was not a requirement.

Academic Major (%)		*Course required for students' academic major?* (%)	
Biology	77.6	Yes	57.7
Pre-medicine	31.6	No	42.3
Education	1.5		
Chemistry	15.3	*School year* (%)	
Math/Computer Science	1.8		
Physics	0.3	Freshman	2.6
Non-science	1.8	Sophomore	5.6
		Junior	24.7
Race/ethnicity (%)		Senior	63.5
		Other	3.6
White/Caucasian	65.3		
Black/African American	4.3	*Gender* (%)	
Hispanic/Latino	6.6		
Asian American	14.0	Male	43.4
Multi-Racial	2.8	Female	56.6
Other	8.9		

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 (52.8%), and Biology: Cell, Molecular, Genetics, Biochemistry (38.5%). Some students were unsure (8.4%), and another 1.5% reported no intentions to pursue an additional degree after undergraduate school.

Graduate education intentions (%)

Medicine	52.8	Education	5.1
Chemistry	4.1	Law	1.5
Physics	0.5	Non-science	2.6
Math/Computer Science	0.8	Don't know	8.4
Biology: Behavior, Ecology of Field Biology	6.9	None	1.5
Biology: Cell, Molecular, Genetics, Biochemistry	38.5		

Prior research experience

Prior to the GCAT program, almost all students had some type of research experience (96.9%). The majority of students had introductory laboratory experience (91.1%), however 3.1% had no form of experience. Students' self-reported laboratory experience is listed below.

Prior research experience (%)

Introductory labs	91.1	Summer research	30.1
Upper level labs	26.3	None	3.1
Independent research	23.0		
Thesis project	9.7		

Completed coursework

Students reported which courses they had completed from the list below. The most common course was introductory biology (95.7%). Calculus (82.9%), Organic chemistry (90.1%), and Physics (65.3%) were also relatively popular among participants. Few students had taken Genomics (3.3%) or Bioinformatics (5.6%) classes.

Courses completed (%)

Introductory biology	95.7	Statistics	53.6
Genetics	71.7	Physics	65.3
Microbiology	38.8	Molecular biology/genetics	42.9
Immunology	19.6	Cell biology	54.1
Inorganic chemistry	51.8	Biochemistry	39.8
Organic chemistry	90.1	Genomics	3.3
Developmental biology	13.0	Bioinformatics	5.6
Neuroscience	11.0	Probability	7.9
Calculus	82.9	None of the above	0.5

Students' GCAT laboratory experience

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 (85.4%). The majority of students were able to do each of the four tasks listed below.

Task	**% of students**
Make their own probe	58.4
Able to get the chips scanned	85.4
Obtained useable data	56.9
Able to analyze his or her own data	62.6

Analysis software

Students 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	3.7
Scananalyze	11.4
JTreeView	2.3
GeneSpring	2.6
Other	0.3
Not applicable	8.9

Student attitudes

After the program, students rated how interested they were in the following areas on a 10-point scale where 1 = *not interested at all* and 7 = *extremely interested.*

Area	**M**	**SD**
Genomics	6.9	2.2
Life Sciences	8.0	1.8
Math/Computer Science	4.7	2.4
Research	7.7	2.2

After the program, 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	4.92	1.41	298
Isolating RNA or genomic DNA to produce probe	5.49	1.24	298
Producing the fluorescently-labeled probe	5.33	1.27	289
Hybridizing the probe with the spotted DNA	5.33	1.34	303
Designing my own experiment	5.14	1.49	233
Analyzing data from public domain source	5.13	1.41	283
Reading papers that used DNA microarrays	5.23	1.45	315

The average effectiveness value students assigned to all of these activities on the 7-point scale was 5.22, and mean scores on individual activities ranged from 4.92 to 5.49; on average, students did not judge any activity to be drastically more or less effective than others. Additionally, almost 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 292 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. With the exception of the final question, 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 average percentage correct across all test items before GCAT was 32.37%. Item 5 was particularly difficult for student participants; only 5.8% of students answered item 5 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 average percentage correct on the post-GCAT survey was 47.88%. Correct responses for each item increased on average by 15.51%. Items 5, 6, and 11 did not show significant improvement after the completion of the GCAT program. Questions 1 and 4, both relating to microarray experimentation, showed particularly large improvements with 36.7% and 34.9% improvement respectively. Knowledge gains and final performance were lowest on items 5 (8.2% correct) and 6 (17.1%); 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. Fewer than half of student participants were able to answer items 2, 3, and 8 correctly after GCAT, and all of these questions pertain to microarray experimentation methods. Although significant gains were observed for these questions, there is 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	26.0	62.7	36.7
2	Microarrary experimentation	31.8	43.2	11.4
3	Microarray experimentation- DNA	35.6	46.9	11.3
4	Microarray experimentation- bacteria	39.4	74.3	34.9
5	Gene expression ratios using a graph	5.8	8.2	2.4
6	Gene expression- probability	15.4	17.1	1.7
7	Gene expression- gene clusters	28.1	57.5	29.4
8	Gene expression using DNA microarray	32.9	49.0	16.1
9	Gene expression in catabolic pathway	39.0	50.0	11.0
10	Gene expression using microarray data	46.6	57.2	10.6
11	Gene expression- microarray technique	55.5	60.6	5.1

* Performance increased significantly ($p \leq 0.05$) on all questions except items 5, 6, and 11.

Control group

Four control classes completed at least one part of the GCAT survey (pre-assessment, post-assessment, or both), totaling 234 students. Of those students, only 43 students completed both the pre and post assessments. Additionally 160 students completed only the post-survey assessment. 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. Because of the small sample of control students that completed both the pre and post knowledge assessments, analyses were conducted with both the 43 students who completed both assessments and the 160 students who completed only the post assessment.

Pre-Post Changes

Students in the control group gained an average of 10.15% correct responses at the end of the semester. 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 $F(1, 333) = 47.94$, $p < .01$, and group $F(1, 333) = 690.94$, $p < .01$. Both groups showed significant increases in score between time one and time two. The GCAT group improved more than the control group, however because the control group improved

and because the sample size of the control group was small ($N = 43$), the interaction of time and group was not found to be statistically significant.

Post-Assessment Differences

A one-way ANOVA was conducted to evaluate the difference between groups on post-assessment knowledge scores. This analysis was chosen because it included more students in the control group than in the previous mixed design. This analysis included 203 control students and 417 GCAT students who completed the post-assessment knowledge test. The ANOVA was significant, $F(1,618) = 68.05$, $p < .01$. This result suggests that students who received the GCAT materials did significantly better at the end of the semester assessment than the control group, who did not receive the GCAT materials. The group that did receive the GCAT materials had a mean post-assessment score of 5.14, compared to the control groups mean score of 3.60.

Faculty

While students identified 40 professors who supervised their use of GCAT materials, 46 faculty members completed the faculty survey at the end of the program, indicating that some students never completed either the pre or post surveys. Four faculty members responded to the survey twice because they used GCAT materials in both semesters of the 2006-2007 school year. Means and standard deviations for the number of students and micro-array chips professors used during the program are reported below. The ratio of students to each micro-array chip was 1.52, and most classes who used GCAT material had less than ten students. On average, only 56.9% of students in each class obtained useable data.

	M	SD
Number of students working with chips	8.47	8.62
Number of micro-array chips used	5.77	3.65
% of students who got useable data from the materials supplied by GCAT	56.9	

Time allotment for laboratory tasks

Professors were asked to estimate the number of hours allocated for each of the tasks in the table below: On average, professors allowed 3.1 hours for each; compared to the other tasks, students were given the most time to analyze their own data (5.93 hours). The least amount of time was allotted for isolating genomic DNA for comparative genome hybridization (.20 hours) and to the students analyzing data from a public domain source (1.49 hours).

Task	M	SD	N
Hybridize probes to microarray	4.73	3.53	44
Isolate mRNA	3.56	2.68	43
Make cDNA probes	3.16	2.62	44
Students design their own experiments	2.82	6.44	39
Students analyze their own data	5.93	7.32	41
Students analyze data from a public domain source	1.49	2.20	43
Isolate genomic DNA for comparative genome hybridization	.20	.77	44
Students practice with software	2.91	2.90	43

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). 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 ($r = .04$, $p = .84$, $N = 25$).

Faculty participants were asked how many hours they spent on each of the seven GCAT activities. These values were totaled to yield a total GCAT time score for each professor. Time scores were quite variable, and it is likely that several are inaccurate. Most scores fell in the range of 15-30 hours for GCAT activities, but some professors report values as low as 3 hours, while other reports were as high as 56 to 67 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.

Because of the small sample of knowledge gain scores for the students, another correlation was computed using the students post knowledge scores. Average post knowledge assessment scores were computed for each instructor (means were separated by semester when professors participated in GCAT during two consecutive semesters). However, the correlation between the total number of hours spent on GCAT activities and the average post knowledge assessment score was also not significant ($r = .25$, $p = .15$, $N = 34$).

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 significant ($r = .36$, $p = .03$, $N = 35$).

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 (84.4%) was the activity chosen most often by the faculty, and only a small percentage had students make total genomic DNA probes (6.7%). Excluding the control group, 80.0% 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	77.8
Make cDNA probes	73.3
Make total genomic DNA probes	6.7
Hybridize probes to a microarray	84.4
Validate the quality of your RNA	66.7
Analyze their own data	68.9
Analyze data from a public domain source	33.3
Design their own experiment	42.2

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 informal feedback (64.4%), and term papers/lab reports were nearly as popular (51.1%). As seen in the adjacent table, other methods were used frequently, including tests (40.0%) and oral presentations (44.4%). 24.4% of professors reported "other" techniques used in addition to those listed here; the least popular way that faculty assessed students was through preparation of a manuscript for publication (8.9%). The "other" option was selected by 24.4% of faculty members in the "please explain" text box next to this option, the following responses were entered to explain the methods used to assess students: homework questions, laboratory notebook, no evaluation, undergraduate research project, an ungraded written assignment, a self generated pre and post assessment, a laboratory practical exam, a multi-staged scientific review paper, a mock grant proposal, and a thesis.

Assessment method	% of professors who used each assessment method
Test	40.0
Term paper/lab report	51.1
Poster presentation	26.7
Oral presentation	44.4
Manuscript for publication	8.9
Course evaluation	28.9
Informal feedback	64.4
Other	24.4

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 (75.6%). 4.4% of professors indicated that they received no funding for using the materials provided by GCAT. Most professors (80.0%) did not feel that their implementation of GCAT materials was limited by computer resources.

Funding source	% professors receiving this type of funding
Departmental	75.6
Institutional	31.1
Extramural	24.4
None	4.4

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	1.62	1.20
The online protocols available on the GCAT website were useful.	4.09	0.85
The GCAT-Listserve was helpful.	4.22	0.67
The collection of other GCAT members as a support network was a significant factor in launching microarry technology on my campus.	3.71	1.20
Overall, I had a positive experience using GCAT.	4.58	0.54
I would use GCAT again in the future.	4.76	0.44

Additional recommendations

There was a dramatic decrease in the number of students who participated in the GCAT survey process. Overall participation in the survey was down by approximately 100 students and participation in both the pre and post surveys was down by more than 100 students (292 students this year, 410 students last year). 392 students responded to the first survey, and 417 responded to the second. In fact, four professors who completed the faculty survey never had any of their students respond to either of the student assessments. Continued efforts should be made to ensure participation by students in both the pre and post surveys. 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. It was brought to our attention that many of the students were completing both of the surveys within hours of each other, which compromised the

results. In addition to the GCAT students, the control group of students who did not experiment with GCAT materials should continue to be included in future GCAT assessments. A larger sample size for these control groups would be helpful in future assessments; it is recommended that GCAT administrators recruit more control students to complete the pre- and post-program surveys. Many of the control students failed to complete both the pre and post assessments, which made it harder to compare this group with the GCAT students.

In the faculty post assessment, many responses had to be eliminated because the faculty failed to follow instructions and thus gave ambiguous answers to many of the survey questions. We may need to revisit how we ask some of the problematic questions. We also want to more accurately determine what the control classes are doing in terms of class work. Because we are seeing improvement in some of the control classes, it is recommended that survey items be developed to identify activities completed by the control classes.