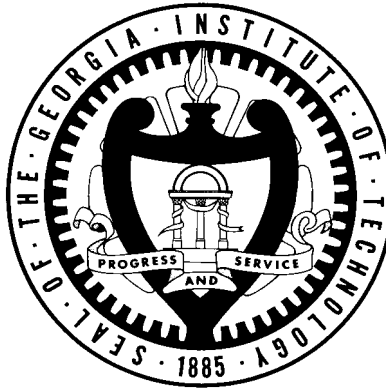




Georgia Institute of Technology

General Education Assessment Report: Mathematics Objective Spring Semester 2004



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The Institute Undergraduate Curriculum Committee's Ad Hoc Subcommittee on General Education developed a set of nine general education objectives for all students earning a Georgia Tech baccalaureate degree. Specifically, the objectives call for:

- Technical, mathematical, and scientific competence
- An ability to communicate to and productively interact with others
- An awareness of culture and values in a diverse world
- An understanding of ethical issues surrounding one's personal and professional activities

The Mathematics Objective as defined by the IUCC and approved by the Faculty Assembly is stated as follows:

Georgia Tech students will be proficient in basic mathematical skills, able to formulate problems mathematically, able to use mathematical methods to solve original problems, and able to demonstrate an understanding of the nature of mathematical reasoning.

The specific assessable learning outcomes stemming from this objective are:

Mathematics Outcome 1: Students will be able to apply basic elements of differential and integral calculus, and linear algebra to relevant problems.

Mathematics Outcome 2: Students will be able to define fundamental mathematical concepts (such as induction, recursion, estimation, and approximation).

Mathematics Outcome 3: Given quantitative data, students will be able to identify trends and other qualitative relationships.

This report covers the assessment of the General Education Mathematics Objective on data collected in Spring 2004. All students at Georgia Tech are required to complete either Math 1501/1502 or Math 1711/1712 as part of the core curriculum.¹ Assessment data was collected from these four courses—Math 1501 (Calculus 1), Math 1502 (Calculus 2), Math 1711 (Finite Mathematics), and Math 1712 (Survey of Calculus). A total of 356 students were included in this assessment. In addition, a question addressing mathematics outcome 1 was included in the final exam of Physics 2211. A similar assessment was conducted in Math 1501 in Fall 2003. However, the previous assessment covered only outcomes 1 and 2.

All of the assessments in Mathematics stem from questions seeded into the final exams in each course. The number of questions and their relative weights varied among the courses, and not all outcomes were specifically addressed in each course. A map of the outcomes covered in each course is provided in Table 1.

To facilitate comparisons across outcomes and courses, the number of points given to each correct response was converted to a ten-point scale. The actual questions used in the assessment are included in an appendix to this report.

In all courses, student responses were matched to demographic information in Banner. Analysis of Variance (ANOVA) was used to determine group differences on the basis of gender, college,

¹ Students enrolled in the Colleges of Architecture, Computing, Engineering or Science complete the 1501/1502 sequence. Students in the College of Management and the Ivan Allen College complete 1711/1712.

student level, and final grade received in the course. Additionally, an ANOVA was performed on the quartile ranking of the admissions index for each student.² In an attempt to preserve homogeneity of variance and to improve the validity of the conclusions, cells with less than 10 students were either combined with other groups or eliminated from the analysis.³ Appropriate post-hoc tests were performed when a significant F statistic was found.⁴

Table 1: Methods Used to Assess General Education Outcomes

	<u>Math 1501</u>	<u>Math 1502</u>	<u>Math 1711</u>	<u>Math 1712</u>	<u>Physics 2211</u>
Math Outcome 1	2 questions	3 questions	3 questions	1 question	1 question
Math Outcome 2	N/A	3 questions	N/A	N/A	N/A
Math Outcome 3	2 questions	2 questions	2 questions	1 question	N/A
Number of Students Included in the Assessment	69	97	141	49	963

The overall results for each General Education Outcome are presented in Table 2. Because these are among the first assessment efforts tied to the new General Education outcomes, no attempt has yet been made to develop benchmarks. It is expected that repeated assessments will yield enough stability in the data to generate such success criteria.

Table 2: Mean Performance Scores by Course

	<u>Outcome 1 Calculus/ Linear Algebra</u>	<u>Outcome 2 Mathematical Concepts</u>	<u>Outcome 3 Trends and Relationships</u>
Math 1501	6.87	n/a	6.54
Math 1502	6.75	6.87	6.38
Math 1711	7.03	n/a	6.87
Math 1712	7.78	n/a	9.08
Physics 2211	5.86	n/a	n/a

² The Admission Index is the product of a regression equation that uses high school GPA and SAT Verbal and Math scores to predict first-year GPA at Georgia Tech. The Index was created by the University System of Georgia, and is used by the Office of Enrollment Services to assist with admissions decisions. To determine the quartile cut points, the Admissions Index for all undergraduate students enrolled at GT in Fall 2003 was used.

³ Groups were combined for admissions index and course grade when necessary. For college comparisons, since there was no logical method of combining the individual colleges, small-n groups were eliminated from the analysis.

⁴ Tukey's HSD or the Games-Howell depending on whether the homogeneity of variance assumption was upheld.

Mathematics Outcome 1: Calculus/Linear Algebra

Students will be able to apply basic elements of differential and integral calculus, and linear algebra to relevant problems.

Math 1501

Two questions (of a multi-part problem) were used to address this outcome. The mean scaled performance on this outcome was 6.87. In the Fall 2003 assessment, the mean was 5.48 (SD=2.84). No significant differences were found on the basis of gender. Significant differences were found in performance based on admission index quartile, as well as course grade. The latter finding validates the conclusion that performance on this outcome is closely related to performance in the overall course. The overwhelming majority of enrollment in this course was from the College of Engineering, thus no comparisons based on college of enrollment were performed.

Table 3: Totals

Mean	6.87
SD	2.38
n	69

Table 4: By Gender

	<u>Female (0)</u>	<u>Male (1)</u>	<u>F</u>	<u>Sig.</u>
Mean	6.52	6.98	0.49	.486
SD	2.36	2.39		
n	17	52		

Table 5: By Course Grade

	<u>A/B (3)</u>	<u>C (2)</u>	<u>D/F (1)</u>	<u>Tukey's HSD</u>	<u>F</u>	<u>Sig.</u>
Mean	8.67	7.23	5.02	3,2>1	15.86	.000***
SD	1.47	2.03	2.20			
n	15	33	21			

Table 6: By Admission Index Quartile

	<u>Highest Quartile/ Third Quartile</u>	<u>Second Quartile</u>	<u>Lowest Quartile</u>	<u>Tukey's HSD</u>	<u>F</u>	<u>Sig.</u>
Mean	7.93	6.94	6.20	3,2>1	5.05	.009**
SD	1.45	2.37	1.96			
N	13	14	41			

Math 1502

Three items in a multi-part question were used to assess this outcome in Math 1502. The scaled mean performance for this outcome was 6.75. No significant differences in performance were found on the basis of gender, college of enrollment, or admission index. There was a significant difference in performance based on course grade, again validating the relationship between achievement of this outcome and overall performance in the course.

Table 7: Totals

Mean	6.75
SD	2.36
n	97

Table 8: By Gender

	Female (0)	Male (1)	<i>F</i>	<i>Sig.</i>
Mean	6.32	6.90	1.11	.294
SD	2.45	2.33		
n	25	72		

Table 9: By College

	College of Engineering (3)	College of Sciences (6)	<i>F</i>	<i>Sig.</i>
Mean	6.76	6.81	0.06	.937
SD	2.53	2.10		
n	67	19		

Table 10: By Course Grade

	A (4)	B (3)	C (2)	D/F (1)	Tukey's HSD	<i>F</i>	<i>Sig.</i>
Mean	8.04	6.88	6.13	5.17	4,3,2>1	4.51	.005**
SD	1.73	2.31	2.04	2.94			
n	18	46	20	12			

Table 11: By Admission Index Quartile

	Highest Quartile	Third Quartile	Second Quartile	Lowest Quartile	<i>F</i>	<i>Sig.</i>
Mean	7.62	6.65	6.28	6.76	0.96	.413
SD	1.88	2.30	2.69	2.36		
N	14	30	24	28		

*p < 0.05; **p < 0.01; ***p < 0.001

Math 1711

Three questions from the final exam were used to assess this outcome. The scaled mean performance was 7.03. No significant differences were found on the basis of gender, college, or admission index (although gender and admission index approached significance at the $p < .05$ level). A significant difference was found on the basis of final course grade, again helping to validate the results of the assessment.

Table 12: Totals

Mean	7.03
SD	2.34
n	141

Table 13: By Gender

	<u>Female (0)</u>	<u>Male (1)</u>	<u>F</u>	<u>Sig.</u>
Mean	7.17	6.86	0.62	.434
SD	2.25	2.45		
n	76	65		

Table 14: By College

	Ivan Allen College <u>(3)</u>	College of Management <u>(6)</u>	<u>F</u>	<u>Sig.</u>
Mean	6.57	7.31	3.51	.063
SD	2.26	2.31		
n	56	81		

Table 15: By Course Grade

	<u>A (4)</u>	<u>B (3)</u>	<u>C (2)</u>	<u>D/F (1)</u>	Games- Howell 4>3,2,1	<u>F</u>	<u>Sig.</u>
Mean	8.16	6.89	5.88	5.15		10.50	.000***
SD	1.61	2.13	2.49	3.09			
n	51	49	29	11			

Table 16: By Admission Index Quartile

	Highest Quartile/ <u>Third Quartile</u>	<u>Second Quartile</u>	<u>Lowest Quartile</u>	<u>F</u>	<u>Sig.</u>
Mean	7.78	6.57	6.96	2.73	.069
SD	2.09	2.35	2.47		
N	33	51	52		

Math 1712

One multi-part question was used to assess outcome 1. The scaled mean score on this outcome was 7.78. There were no significant differences found among gender or college. A significant difference was found for final course grade. There were not enough students in each quartile of admission index to perform an analysis based on this factor.

Table 17: Totals

Mean	7.78
SD	2.03
N	49

Table 18: By Gender

	<u>Female (0)</u>	<u>Male (1)</u>	<u>F</u>	<u>Sig.</u>
Mean	7.56	8.05	0.70	.407
SD	2.22	1.79		
N	27	22		

Table 19: By College

	Ivan Allen College <u>(3)</u>	College of Management <u>(6)</u>	<u>F</u>	<u>Sig.</u>
Mean	7.61	7.92	0.29	.594
SD	2.29	1.81		
N	23	26		

Table 20: By Course Grade

	A <u>(4)</u>	B <u>(3)</u>	C/D/F <u>(2)</u>	Games- Howell 4>2	<u>F</u>	<u>Sig.</u>
Mean	8.93	7.61	6.73		4.91	.012*
SD	1.44	2.15	1.94			
N	14	18	15			

Physics 2211

One item from the final exam was used to assess this outcome. The scaled mean score for this outcome was 5.87. There were no significant differences found among gender, college, or student level. Significant differences were found on the basis of admission index and final course grade.

Table 21: Totals

Mean	5.87
SD	4.93
N	963

Table 22: By Gender

	<u>Female (0)</u>	<u>Male (1)</u>	<u>F</u>	<u>Sig.</u>
Mean	5.53	5.96	1.19	.275
SD	4.98	4.91		
N	199	764		

Table 23: By College

	<u>College of Architecture (1)</u>	<u>College of Computing (2)</u>	<u>College of Engineering (3)</u>	<u>College of Sciences (6)</u>	<u>F</u>	<u>Sig.</u>
Mean	5.20	5.86	5.92	4.90	0.85	.468
SD	5.10	4.97	4.92	5.05		
N	25	58	814	53		

Table 24: By Student Level

	<u>Freshman</u>	<u>Sophomore</u>	<u>Junior</u>	<u>Senior</u>	<u>F</u>	<u>Sig.</u>
Mean	5.86	5.99	6.38	3.33	1.81	.144
SD	4.93	4.91	4.86	4.85		
N	691	207	47	18		

Table 25: By Course Grade

	<u>A (4)</u>	<u>B (3)</u>	<u>C (2)</u>	<u>D (1)</u>	<u>F (0)</u>	<u>Games- Howell</u>	<u>F</u>	<u>Sig.</u>
Mean	9.15	6.65	5.85	4.46	3.98	4>3,2>1,0	19.62	.000***
SD	2.80	4.73	4.93	4.98	4.92			
n	106	224	311	202	118			

Table 26: By Admission Index Quartile

	<u>Highest Quartile</u>	<u>Third Quartile</u>	<u>Second Quartile</u>	<u>Lowest Quartile</u>	<u>Games- Howell</u>	<u>F</u>	<u>Sig.</u>
Mean	6.87	5.70	5.10	5.60	4>3,2,1	5.42	.001**
SD	4.65	4.95	5.01	4.98.			
N	230	279	241	193			

Mathematics Outcome 2: Mathematical Concepts

Students will be able to define fundamental mathematical concepts (such as induction, recursion, estimation, and approximation).

Math 1502

Two questions from a multi-part problem were used to assess this outcome. The scaled mean performance on this outcome was 6.87. No significant differences were found on the basis of gender, college, or admission index. There were significant differences in performance based on final course grade.

Table 27: Totals

Mean	6.87
SD	2.52
N	97

Table 28: By Gender

	<u>Female (0)</u>	<u>Male (1)</u>	<u>F</u>	<u>Sig.</u>
Mean	6.59	6.96	0.41	.523
SD	2.41	2.57		
n	25	72		

Table 29: By College

	College of Engineering (3)	College of Sciences (6)	<u>F</u>	<u>Sig.</u>
Mean	6.92	7.19	0.20	.672
SD	2.57	2.27		
n	19	67		

Table 30: By Course Grade

	A (4)	B (3)	C (2)	D/F (1)	Games- Howell 4>3>2,1	<u>F</u>	<u>Sig.</u>
Mean	8.85	7.13	5.20	5.61		9.88	.000***
SD	1.60	2.45	2.21	2.23			
n	18	46	20	12			

Table 31: By Admission Index Quartile

	Highest Quartile	Third Quartile	Second Quartile	Lowest Quartile	<u>F</u>	<u>Sig.</u>
Mean	7.86	6.80	6.03	7.14	1.75	.163
SD	2.14	2.84	2.37	2.39		
N	14	30	24	28		

Mathematics Outcome 3: Trends and Relationships

Given quantitative data, students will be able to identify trends and other qualitative relationships.

Math 1501

Two questions from a multi-item problem were used to assess this outcome. The scaled mean score for this outcome was 6.54. There were no significant difference in performance based on gender, admission index or course grade.

Table 32: Totals

Mean	6.54
SD	2.00
n	69

Table 33: By Gender

	<u>Female (0)</u>	<u>Male (1)</u>	<u>F</u>	<u>Sig.</u>
Mean	5.88	6.76	2.52	.117
SD	2.01	1.96		
n	17	52		

Table 34: By Course Grade

	<u>A/B (3)</u>	<u>C (2)</u>	<u>D/F (1)</u>	<u>F</u>	<u>Sig.</u>
Mean	7.14	5.45	6.26	0.92	.402
SD	2.41	1.89	1.83		
n	15	33	21		

Table 35: By Admission Index Quartile

	<u>Highest Quartile/ Third Quartile</u>	<u>Second Quartile</u>	<u>Lowest Quartile</u>	<u>F</u>	<u>Sig.</u>
Mean	7.14	6.94	6.20	1.46	.240
SD	1.65	2.37	1.96		
N	13	14	41		

Math 1502

Two problems from a multi-item question were used to assess the outcome. The scaled mean score on this outcome was 6.38. No significant differences were found on the basis of gender, college or admission index. There was a significant difference found on the basis of final course grade.

Table 36: Totals

Mean	6.38
SD	3.45
n	97

Table 37: By Gender

	<u>Female (0)</u>	<u>Male (1)</u>	<u>F</u>	<u>Sig.</u>
Mean	5.36	6.74	3.02	.086
SD	3.21	3.48		
n	25	72		

Table 38: By College

	<u>College of Engineering (3)</u>	<u>College of Sciences (6)</u>	<u>F</u>	<u>Sig.</u>
Mean	6.42	6.58	0.03	.861
SD	3.67	2.91		
n	67	19		

Table 39: By Course Grade

	<u>A (4)</u>	<u>B (3)</u>	<u>C (2)</u>	<u>D/F (1)</u>	<u>Games-Howell</u>	<u>F</u>	<u>Sig.</u>
Mean	8.06	6.72	5.00	4.58	4,3>2,1	4.08	.009**
SD	2.51	3.38	2.81	4.50			
n	18	46	20	12			

Table 40: By Admission Index Quartile

	<u>Highest Quartile</u>	<u>Third Quartile</u>	<u>Second Quartile</u>	<u>Lowest Quartile</u>	<u>F</u>	<u>Sig.</u>
Mean	7.14	6.33	5.83	6.39	0.42	.739
SD	2.57	3.46	3.81	3.58		
N	14	30	24	28		

Math 1711

Two questions were used to assess the outcome. The scaled mean score on this outcome was 6.87. While no significant differences were found on the basis of admission index or college, there were significant differences found on the basis of gender (with females outperforming males) and on the basis of final course grade.

Table 41: Totals

Mean	6.87
SD	2.48
n	141

Table 42: By Gender

	Female (0)	Male (1)	<i>F</i>	<i>Sig.</i>
Mean	7.32	6.34	5.68	.018*
SD	2.35	2.54		
n	76	65		

Table 43: By College

	Ivan Allen College (3)	College of Management (6)	<i>F</i>	<i>Sig.</i>
Mean	6.65	6.97	0.60	.442
SD	2.28	2.56		
n	56	81		

Table 44: By Course Grade

	A (4)	B (3)	C (2)	D/F (1)	Tukey's HSD	<i>F</i>	<i>Sig.</i>
Mean	8.31	6.60	5.56	4.60	4>3,2>1	15.46	.000***
SD	2.02	2.21	2.29	2.22			
n	51	49	29	11			

Table 45: By Admission Index Quartile

	Highest Quartile/ Third Quartile	Second Quartile	Lowest Quartile	<i>F</i>	<i>Sig.</i>
Mean	7.66	6.59	6.67	2.22	.113
SD	2.51	2.45	2.42		
N	33	51	52		

*p < 0.05; **p < 0.01; ***p < 0.001

Math 1712

One multi-item question was used to assess the outcome. The scaled mean score on this question was 9.08. No significant differences were found on the basis of gender, college or final course grade (although the latter factor approached significant at the $p < .05$ level).

Table 46: Totals

Mean	9.08
SD	1.55
n	49

Table 47: By Gender

	Female (0)	Male (1)	<i>F</i>	<i>Sig.</i>
Mean	9.07	9.09	0.01	.970
SD	1.56	1.58		
n	27	22		

Table 48: By College

	Ivan Allen College (3)	College of Management (6)	<i>F</i>	<i>Sig.</i>
Mean	9.49	8.72	3.18	.081
SD	0.86	1.92		
n	23	26		

Table 49: By Course Grade

	A (4)	B (3)	C/D/F (2)	<i>F</i>	<i>Sig.</i>
Mean	9.46	9.35	8.28	2.83	.070
SD	1.78	0.97	1.77		
n	14	18	15		

Conclusion

The results of the assessment in mathematics establish a baseline for student performance in the core courses. Students appear to be able to master the requisite skills regardless of gender, college or admission index. The fact that student performance is significantly related to final course grade in many instances helps to validate the assessment methodology.