

UTILIZATION, FUNCTIONALITY, AND EFFECTIVENESS OF THE QUARTER-BASED GENERAL COLLEGE PREPARATORY MATHEMATICS PROGRAM

Full Report

Spring 2001

Office of Research and Evaluation

This report presents results of research that was conducted in order to examine the relationship between preparatory college mathematics course taking and performance in subsequent college-level mathematics courses. First, preparatory mathematics course taking patterns and performance outcomes were examined. Second, the relationship between these patterns and outcomes, and registration for, and performance in, subsequent mathematical thinking courses was examined. Finally, performance in Mathematical Thinking courses was compared between students who had taken preparatory mathematics and those who had not.

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The Preparatory Mathematics Curriculum

General College offers mathematics courses for students who lack the pre-requisite skills and concepts necessary for college level mathematics. Under the quarter system, the General College mathematics curriculum contained a sequence of five preparatory mathematics courses. General College students would work with advisors in determining the appropriate point at which to begin the sequence. The following quantitative and qualitative information would commonly be used to guide decisions: scores from a math placement test required of all students matriculating into General College; ACT test scores and high school mathematics record; students' attitudes and affective states regarding mathematics; and students' intended program of study. Enrollment in these courses was not restricted only to GC students; Students from other colleges did enroll in these courses, presumably because they had been referred to such courses by the Math department.

GC 0611, Introduction to Basic Mathematics, and GC 0615, Introduction to Mathematical Problem Solving, comprised the absolute base of the sequence. Very few students began at this level, however. Next in the sequence were a series of three algebra courses. They are listed below with their course descriptions as presented in the 1997-1999 General College Bulletin:

GC 0621 Elementary Algebra (pre-requisite- GC math placement or GC 0611 or GC 0615). For students with strong background in arithmetic. Content: Sets, properties, signed numbers, equations, word problems, inequalities, graphing, polynomials, factoring, rational expressions, radicals.

GC 0625 Intermediate Algebra I (pre-requisite- GC math placement or Elementary Algebra with grade of C or better). For students with adequate background in elementary algebra. Content: Sets, real numbers, linear equations, linear inequalities, absolute value equations and inequalities, exponents, polynomials, systems of equations, word problems, rational expressions, roots, radicals.

GC 0631 Intermediate Algebra II (pre-requisite- GC math placement or GC 0625 with grade of C or better). Content: Complex numbers, quadratic equations, matrix solutions to systems of equations, general inequalities, conic sections, functions, logarithmic and exponential functions, sequences, series, binomial theorem. Knowledge of linear and quadratic equations and inequalities, exponents, factoring, rational expressions, roots, radicals, and graphing assumed.

Completing GC 0631 with a grade of C or better was a pre-requisite for common college-level mathematics courses such as College Algebra and Probability, and Precalculus I.

Sample of Students

Registration records were accessed from the University of Minnesota's Student Registration Database for all students registered in a General College (GC) preparatory mathematics course under the quarter system between Fall 1994 and Fall 1998. For each student in these records, the last preparatory math course that they had completed was determined. All cases where the last preparatory math course was taken in Summer session, or as an Extension (evening) course, were dropped from the data file. Students who had taken a college-level mathematics course before the last preparatory math course were also dropped from the analyses: 87 cases were eliminated for this reason. Finally, students who were not Freshman or Sophomores at the time of their last preparatory math course were dropped from the analysis (N=134). The resulting sample of students who had taken preparatory mathematics (N=2,821) was subdivided in several different ways: First students were separated by whether or not they were in General College at the time of their last preparatory math course: 2,202 students were in GC at the time of their last preparatory math course, and 619 were registered with another program, only a small percentage of whom (7.4%, N=46) actually began in GC. Second, in order to capture preparatory mathematics course-taking patterns, students were separated into the following mutually exclusive Preparatory Math History (PMH) groups: took only Elementary Algebra (11%, N=309), took Elementary and Intermediate Algebra I (5.1%, N=145), took only Intermediate Algebra I (19.8%, N=559), took Elementary, and Intermediate Algebra I and II (11.8%, N=333), took Intermediate Algebra I and II (31.8%, N=897), and took only Intermediate Algebra II (18.7%, N=528). There were 50 students who did not fit into one of the PMH groups either because they had only taken Introduction to Basic Mathematics (GC 0611) or because they took, for example, Intermediate Algebra I before Elementary Algebra. The table below presents PMH group distributions for students who were in GC at the time of their last preparatory mathematics course and students who were not.

Table 1: Preparatory Math History Group Distribution

	<i>GC Freshman or Sophomore at time of last preparatory math</i>		<i>Non-GC Freshman or Sophomore at time of last preparatory math</i>	
	Frequency	Percent	Frequency	Percent
Took only 0621	283	12.9%	26	4.2%
Took 0621 and 0625	130	5.9%	15	2.4%
Took only 0625	456	20.7%	103	16.6%
Took 0621, 0625, and 0631	255	11.6%	59	9.5%
Took 0625 and 0631	706	32.1%	191	30.9%
Took only 0631	310	14.1%	218	35.2%
Other sequence	62	2.8%	7	<1%
Total	2202	100%	619	100.0

The first non-GC college-level math course taken after the last preparatory math course was found for each student (referred to as "subsequent" non-GC Mathematical Thinking course in the report). Any non-GC college-level quarter system course (i.e. up to Summer 1999) which met the University's Mathematical Thinking (MT) requirement defined the scope of all possible "first college-level math courses". Students' registration records were also pulled for GC 1454 (Statistics) and GC 1456 (Functions and Problems of Logic), two General College courses which met the University's Mathematical Thinking requirement.

In order to compare non-GC mathematical thinking course grades between preparatory math and non-preparatory math students, non-GC MT course records were divided into five groups comprised of: students who had taken preparatory mathematics while in GC; students who had taken preparatory mathematics while not in GC; CLA freshman and sophomores who had not taken preparatory mathematics; students who started out in GC but did not take preparatory mathematics.

Preparatory Math Course Registration and Performance, and Subsequent Mathematical Thinking Course Registration

This Section describes preparatory math course taking behaviors and subsequent Mathematical Thinking (MT) course registration primarily for students who were in General College at the time of their last preparatory math course (N=2,202). At various points, for comparative purposes, data are presented from the group of 619 non-GC students who took preparatory mathematics courses. Also examined in this section is the relationship between preparatory math history and preparatory math course performance, and registration for, and performance in, subsequent mathematical thinking courses.

Intermediate Algebra II (GC 0631) was the last preparatory math course for a little over half of the GC students, and the majority of the non-GC students. Below is the distribution of last preparatory math course for these two groups. Following this table are several others examining in more detail preparatory math course history for students who were in General College at the time of their last preparatory math course.

Table 2: Distribution of Last Preparatory Math Course

<i>Last preparatory mathematics course taken (during/after F94)</i>	<i>GC Freshman or Sophomore at time of last preparatory math</i>		<i>Non-GC Freshman or Sophomore at time of last preparatory math</i>	
	Frequency	Percent	Frequency	Percent
Introduction to Basic Mathematics (GC 0611)	20	<1%	1	<1%
Elementary Algebra (GC 0621)	308	14%	27	4%
Intermediate Algebra I (GC 0625)	587	27%	120	19%
Intermediate Algebra II (GC 0631)	1287	58%	471	76%
Total	2202	100%	619	100%

46% of GC students took only one preparatory math course, 39% of students took two, 13% took three, and about 2% took four. 7.8% of students were taking the last preparatory mathematics course as a repeat.

Table 3: Number of Preparatory Math Courses Taken (Including Last Preparatory Math) by GC Students

Number of preparatory math courses taken	Frequency	Percent	Cumulative Percent
One	1004	45.6%	45.6%
Two	866	39.3%	84.9%
Three	289	13.1%	98.0%
Four	43	2.0%	100%
Total	2202	100%	

The table below shows, among other things, that GC students whose last preparatory math course was Elementary Algebra (GC 0621) were more likely to have taken this course as a repeat than students whose last course was

Intermediate Algebra I (GC 0625) or II (GC 0631). GC 0621 was a repeat course for 13% of the students whose last preparatory math course was GC 0621; GC 0625 was a repeat course for 6% of the students whose last preparatory math course was GC 0625; and GC 0631 was a repeat course for 7% of the students whose last preparatory math course was GC 0631.

Table 4: Prior Preparatory Math Courses Taken by GC Students Whose Last Preparatory Math Course Was 0611, 0621, 0625, or 0631

Last preparatory math course was:	Preparatory math taken before last preparatory math course:	Frequency	Percent
GC 0611	GC 0611	0	--
	GC 0621	1	5%
	GC 0625	0	--
	GC 0631	0	--
GC 0621	GC 0611	21	6.8%
	GC 0621	40	13%
	GC 0625	4	1.3%
	GC 0631	0	--
GC 0625	GC 0611	5	<1%
	GC 0621	130	22.1%
	GC 0625	33	5.6%
	GC 0631	0	
GC 0631	GC 0611	12	<1%
	GC 0621	271	21.1%
	GC 0625	961	74.7%
	GC 0631	95	7.4%

Preparatory Math Course Grades

Analysis of Variance methods were used to examine differences in preparatory math course grade between students whose last preparatory math course was Elementary Algebra (GC 0621), Intermediate Algebra I (GC 0625), or Intermediate Algebra II. This analysis focused only on the 2,202 students who were in GC at the time of their last preparatory math course. The "significance" of group differences was gauged by the effect size, which can be interpreted as the proportion of variance in the dependent variable attributable to the independent variable (which in this case was "last preparatory math course"). Effect size is analogous to the squared correlation coefficient between dependent and independent variables. The effect size for last preparatory math course on course grade was large (effect size (h^2)=.06): there was a statistically significant positive relationship between course grades and last preparatory math course taken. Students' level of pre-college math achievement could be one possible explanation for this relationship, since *where* students begin in the math sequence depends upon this factor. In order to control for this confound, ACT Math score and High School Math GPA were used as covariates in the analysis. After controlling for these variables, the relationship was still present, though less strong (effect size (h^2)=.02).

Table 5: Grade in Last Preparatory Math by Highest Preparatory Math Course Taken (GC students only)

<i>last preparatory math course taken (during/after F94)</i>	<i>Mean grade</i>	<i>Std. Deviation</i>	<i>Percent passing (grade of C- or above)</i>	<i>N</i>
Elementary Algebra (GC 0621)	1.27	1.29	43%	260
Intermediate Algebra I (GC 0625)	2.10	1.40	70%	550
Intermediate Algebra II (GC 0631)	2.27	1.21	79%	11

*not adjusted for covariates- N based on all students who had ACT and HS math GPA

Another possible explanation for the relationship is Persistence; students who only went as far as Elementary Algebra (GC 0621) may have done so *because* they dropped out shortly thereafter, and, past research shows that students who drop out tend to have lower grades. In order to control for this "persistence" effect, persistence 2 years after taking last preparatory math course was added as a covariate. With this analysis the effect size was reduced to what would be considered "small" (effect size (h^2)=.01). Once persistence and pre-college math background were controlled, there was little difference between course grades for students who stopped at 0625 or 0631, but students who only went as far as 0621 still received significantly lower grades.

Table 6: Grade in Last Preparatory Math by Highest Preparatory Math Course Taken for GC Students Who Were Still Enrolled at the University 2 Years After Taking Their Last Preparatory Math Course

<i>Last preparatory math course taken (during/after F94)</i>	<i>Mean grade</i>	<i>Std. Deviation</i>	<i>Percent passing (grade of C- or above)</i>	<i>N</i>
Elementary Algebra (GC 0621)	1.70	1.34	59%	81
Intermediate Algebra I (GC 0625)	2.59	1.17	85%	247
Intermediate Algebra II (GC 0631)	2.54	1.07	87%	745

*not adjusted for covariates- N based on all students who had ACT and HS math GPA

For some reason, not wholly attributable to pre-college math background and persistence, students who only went as far as Elementary Algebra (GC 0621) received significantly lower grades in that course. Historically, grades in GC 0621 tend to be lower than grades earned in Intermediate Algebra I or II (GC 0625 or 0631), but further analysis (see table 7 below) revealed that persisting students who stopped at 0621 received 0621 grades significantly lower than other 0621 students who went on to take 0625 and/or 0631.

Table 7: Average Grades in Elementary Algebra (GC 0621) for Persisting and Non-Persisting GC Students Whose Last Preparatory Math Course Was Elementary Algebra, Intermediate Algebra I (GC 0625) or Intermediate Algebra II (GC 0631)

	<i>Not retained 2 years after last preparatory math</i>				<i>Retained 2 years after last preparatory math</i>			
	<i>Mean grade</i>	<i>SD</i>	<i>% Passing</i>	<i>N</i>	<i>Mean grade</i>	<i>SD</i>	<i>% Passing</i>	<i>N</i>
Took 0621 and went as high as 0631	2.66	.96	91%	117	2.73	.91	92%	154
Took 0621 and went as high as 0625	2.29	1.00	87%	67	2.45	.91	89%	63
Took 0621 and went no further with preparatory math	1.01	1.21	34%	215	1.66	1.31	58%	93

passing defined as a grade of C- or better

Finally, preparatory mathematics course grades were examined by Preparatory Math History (PMH) group. Within each PMH group, last preparatory math course grades were compared between GC students and non-GC students. Descriptive statistics can be found in the table below. Non-GC students who took 0625 and 0631 or only 0631 received 0631 grades significantly higher than GC students who took 0625 and 0631 or only 0631. However, the non-GC students tended to have a stronger pre-college math background, and indeed, once ACT Math score and High School math GPA are accounted for, the differences in 0631 grade cease to be significant.

Table 8: Grade in Last Preparatory Math Course by Preparatory Math History Group and GC/Non-GC Student Status

<i>Preparatory Math History Group</i>	<i>GC Freshman or Sophomore at time of last preparatory math</i>	<i>Non-GC Freshman or Sophomore at time of last preparatory math</i>
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	Mean	Std. Deviation	N	Mean	Std. Deviation	N
	grade			grade		
Took only 0621	1.26	1.27	283	1.67	1.65	26
Took 0621 and 0625	1.83	1.32	130	2.16	1.41	15
Took 0621, 0625, and 0631	1.88	1.22	271	2.01	1.33	62
Took only 0625	2.15	1.41	456	2.13	1.48	103
Took 0625 and 0631	2.29	1.21	706	2.84	1.18	191
Took only 0631	2.47	1.19	310	2.67	1.12	218

Further observation of the data in Table 8 reveals another interesting pattern: GC students' grade in their last preparatory mathematics course was related to their preparatory math history. Specifically, a). Intermediate Algebra II students who took no preparatory mathematics courses before GC 0631 tended to earn higher grades in that course than Intermediate Algebra II students who started out in Intermediate Algebra I or Elementary Algebra, and b). Intermediate Algebra I students who took no preparatory mathematics courses before GC 0625 tended to earn higher grades in that course than Intermediate Algebra I students who started out in Elementary Algebra. These differences were not wholly attributable to students' *general* college performance. Though GPA's (not including preparatory math grade) for the term in which the last preparatory math was taken follow a pattern similar to preparatory math course grades, this pattern was less marked- statistically speaking, when controlling for term GPA, the differences in preparatory math course grade are still significant.

Registration for Subsequent Mathematical Thinking Courses

The first non-GC college-level math course taken after the last preparatory math course was found for each student. Any non-GC college-level quarter system course (i.e. up to Summer 1999) which met the University's Mathematical Thinking (MT) requirement defined the scope of all possible "first college-level math courses". Below is a frequency distribution for subsequent non-GC college-level math courses taken by GC and non-GC students who had taken preparatory math. Most GC students who took a subsequent non-GC MT course (67% overall) did so in the term immediately following the term in which the last preparatory math course was taken; 19% did so within 1 year after their last preparatory math course, and 14% let at least 1 year pass before they took their first non-GC MT course.

Table 9: First Non-GC College-Level Math Courses Taken by Students Who Took Preparatory Math

	<i>GC Freshman or Sophomore at time of last preparatory math</i>		<i>Non-GC Freshman or Sophomore at time of last preparatory math</i>	
	Frequency	Percent	Frequency	Percent
No subsequent non-GC Mathematical Thinking course	1063	48.3%	180	29.1%
Excursions in Mathematics (Math 1001)*	18	<1%	16	2.6%
Introduction to Logic (Philosophy 1001)	46	2.1%	27	4.4%
Introduction to Ideas of Statistics (Statistics 1001)	65	3.0%	44	7.1%
College Algebra and Probability (Math 1031)*	583	26.5%	230	37.2%
Mathematics and Our Universe (Astronomy 1040)	4	<1%	4	<1%
Precalculus I (Math 1051)*	351	15.9%	94	15.2%
Short Calculus (Math 1142)**	12	<1%	1	<1%
Precalculus II (Math 1151)**	10	<1%	0	--
One Variable Integral & Differential Calculus I (Math 1251)**	11	<1%	1	<1%
Statistical Analysis (Statistics 3011)**	5	<1%	2	<1%
Basic and Applied Statistics (Educational Psychology 3260)	7	<1%	2	<1%
Introduction to Statistical Methods (Psychology 3801)*	27	1.2%	17	2.7%
Total	2202	100.0	619	100.0

* Completion of Intermediate Algebra II (GC 0631) is a direct pre-requisite

** Completion of Intermediate Algebra II (GC 0631) is an indirect pre-requisite

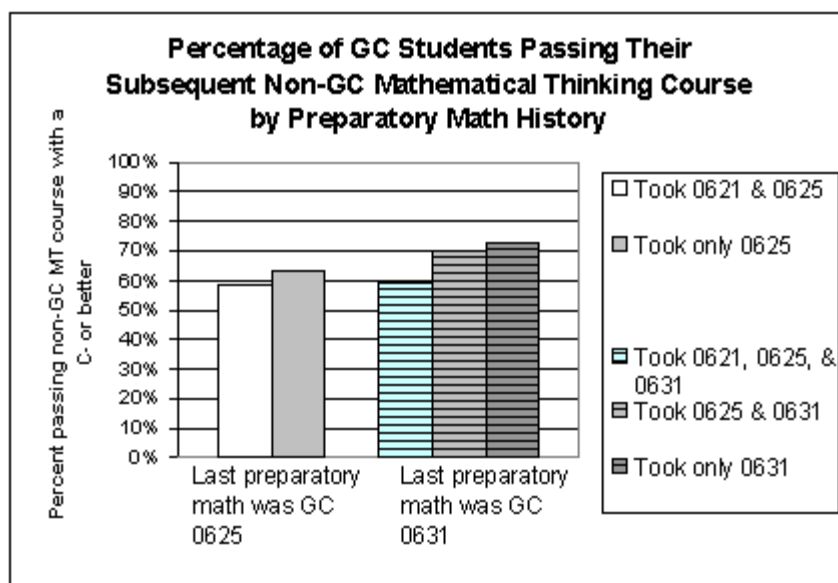
GC Students were more likely to take a subsequent non-GC MT course if they had taken Intermediate Algebra II (GC 0631). Only 27 % of students who took at most 0621 and were still enrolled at the University 2 years later had taken a subsequent non-GC MT course under the quarter system, but, 71% of students who began in 0621, and went on to 0631 had taken a subsequent non-GC MT course under the quarter system. This is understandable given that successful completion of Intermediate Algebra II is a pre-requisite for many of the courses listed in Table 9.

Table 10: Percentage of GC Students Taking a Subsequent Non-MT Course and Percent Passing the Course by Preparatory Math History

Preparatory Math History Group	All GC students				GC Students retained 2 years after last preparatory math			
	%	Frequ	% passing non-GC MT course	Total N	%	Frequ	% passing non-GC MT course	Total N
Took only 0621	12.4	35	60%	283	27.0	24	71%	89
Took 0621 and 0625	27.7	36	58%	130	47.6	30	60%	63
Took 0621, 0625, and 0631	55.4	150	59%	271	70.3	109	61%	155
Took only 0625	35.7	163	63%	456	58.9	119	69%	202
Took 0625 and 0631	72.4	511	70%	706	84.9	393	73%	463
Took only 0631	78.4	243	73%	310	90.5	162	77%	179

passing defined as grade of C- or better in the course

Performance in subsequent non-GC MT courses is related to preparatory math history, as illustrated in the figure below.



A substantial proportion of GC students did not take a subsequent non-GC MT course under the quarter system. There are two possible explanations for why these students did not take a subsequent non-GC MT course: First, they may have left the University shortly after their last preparatory math course, and second, since in order to fulfill the Mathematical Thinking requirement students only need one MT course, these students might have chosen to fulfill their MT requirement by taking GC 1454 (Statistics) or GC 1456 (Functions and Problems of Logic). Both explanations seem to be corroborated by the data. When looking at all students regardless of persistence, 48% (N=1063) did not take a non-GC MT course within the quarter system, however 26% (of these 1063 students) did take

GC 1454 or GC 1456. When considering only students who were retained in their third year, the percentage statistic for students who did not take a subsequent non-GC MT course drops to 28%, but 54% of these students did take GC 1454 or GC 1456. So, in the end it appears that 13% of persisting GC students who took preparatory math had not fulfilled their MT requirement. This figure may be somewhat inflated, since a larger proportion of students who had not taken an MT course had begun at the University in Fall 1998, thus giving them only one year to take preparatory math and an MT course.

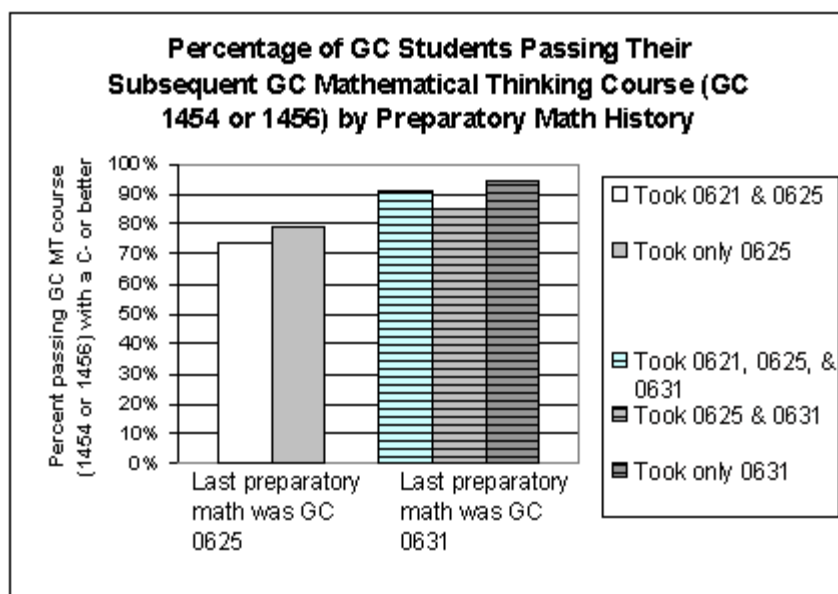
GC Students were more likely to have taken GC 1454 or GC 1456 if they had only completed 0621. 39% of students who took at most 0621 and were still enrolled at the University 2 years later had taken either GC 1454 or GC 1456 under the quarter system; 29% of students who began in 0621, but went on to 0631 had taken GC 1454 or GC 1456; and only 16% of students who only took 0631 also took GC 1454 or GC 1456.

Table 11: Percentage of Students Who Took GC 1454 (Statistics) or GC 1456 (Functions and Problems of Logic) and Percent Passing the Course by Preparatory Math History

Preparatory Math History Group	All GC Students			GC Students Retained 2 years after last Preparatory math		
	% taking GC 1454/1456	Frequency taking GC 1454/1456	% passing GC 1454/1456	% taking GC 1454/1456	Frequency taking GC 1454/1456	% passing GC 1454/1456
Took only 0621	20%	35.00	75%	39%	35	86%
Took 0621 and 0625	24%	22.00	74%	35%	22	82%
Took 0621, 0625, and 0631	25%	45.00	91%	29%	45	96%
Took only 0625	21%	65.00	79%	32%	65	85%
Took 0625 and 0631	20%	106.00	85%	23%	106	89%
Took only 0631	12%	29.00	94%	16%	29	100%

passing defined as a grade of C- or better in the course

As Table 11 above and the chart below illustrate, students whose last preparatory math course was Intermediate Algebra were somewhat less likely to pass GC Mathematical Thinking courses than students who had taken Intermediate Algebra II.



Comparison of Performance in Mathematical Thinking Courses Between Students Who Had Taken Preparatory Mathematics and Those Who Had Not

Below is a table displaying the average grades earned in the subsequent Mathematical Thinking (MT) courses taken by the (1,578 of 2,821) students who began in preparatory math. Average grades earned by students who did not begin in preparatory math are also displayed, but only for Math 1031, Math 1051, Philosophy 1001, and Statistics 1001, the four non-GC MT courses most frequently taken after preparatory math.

Table 12: Average Grades in Mathematical Thinking Courses Earned by Preparatory Math Students and All Non-Preparatory Math Students

	<i>GC Freshman or Sophomore at time of last preparatory math</i>			<i>Non-GC Freshman or Sophomore at time of last preparatory math</i>			<i>Did not begin in preparatory math</i>		
	Mean	SD	Valid N	Mean	SD	Valid N	Mean	SD	Valid N
Math 1001	2.222	1.35	N=18	2.271	1.24	N=16	--	--	--
Philosophy 1001	1.783	1.27	N=46	1.691	1.16	N=27	2.611	1.22	N=3404
Statistics 1001	1.933	.93	N=65	2.371	1.12	N=44	2.797	1.00	N=1741
Math 1031	1.848	1.07	N=583	2.049	1.07	N=230	2.181	1.18	N=3402
Astronomy 1040	1.668	.47	N=4	2.000	.00	N=4	--	--	--
Math 1051	2.045	1.19	N=351	2.159	1.21	N=94	2.250	1.21	N=2290
Math 1131	--	--	--	3.000	--	N=1	--	--	--
Math 1142	1.723	1.33	N=12	2.000	--	N=1	--	--	--
Math 1151	2.299	.96	N=10	--	--	--	--	--	--
Math 1251	.545	.69	N=11	2.000	--	N=1	--	--	--
Statistics 3011	1.532	1.02	N=5	1.500	.71	N=2	--	--	--
Educational Psychology 3260	2.096	1.52	N=7	3.500	.71	N=2	--	--	--
Psychology 3801	1.94	.83	N=27	2.35	.79	N=17	--	--	--

Analyses were conducted to determine the relationship between last preparatory math course grades and subsequent non-GC MT course grades. Both students who were in GC and those who were not in GC at the time of their last preparatory math course are included in this analysis. Grade earned in last preparatory math course (considering last preparatory math courses of 0625 or 0631) was correlated with grade earned in subsequent non-GC MT courses ($r=.45$ for Math 1031; $r=.49$ for Math 1051; $r=.55$ for Philosophy 1001; $r=.45$ for Statistics 1001). This relationship appears to hold regardless of whether the last preparatory math course was 0625 or 0631, though students tended to earn lower grades in 1031/1051 if they had completed only 0625. Tables 13 and 14 below show cross-tabulations between GC 0631 grade and Math 1031/1051 grade for all students who had taken 0631. Because there were relatively few students who took 1031/1051 and whose last preparatory math course was 0625, cross-tabulations are not shown for this group; For this group, tables 15 and 16 below show average grades earned in 1031/1051 and 1031/1051 pass rates broken out by 0625 course grade.

Table 13: GC 0631 Grade by Math 1031 Grade

0631 grade	<i>Math 1031 grade</i>										<i>Mean 1031 grade</i>	<i>Total N</i>
	A		B		C		D		F			
	N	%	N	%	N	%	N	%	N	%		
A	39	22.9%	57	33.5%	62	36.5%	7	4.1%	5	2.9%	2.70	170
B	10	3.8%	74	27.9%	116	43.8%	52	19.6%	13	4.9%	2.07	265
C	4	2.1%	13	6.7%	84	43.5%	65	33.7%	27	14.0%	1.50	193
D			5	11.4%	14	31.8%	11	25.0%	14	31.8%	1.21	44
F			1	5.6%	3	16.7%	6	33.3%	8	44.4%	.83	18

For all students who were Freshmen or Sophomores when they took 0631, including students who were not in GC while taking 0631

Table 14: GC 0631 Grade by Math 1051 Grade

|--|--|--|--|--|--|--|--|--|--|--|--|

0621 Grade	Math 1051 grade										Mean 1051 grade	Total N
	A		B		C		D		F			
	N	%	N	%	N	%	N	%	N	%		
A	43	35.5%	40	33.1%	25	20.7%	10	8.3%	3	2.5%	2.91	121
B	7	5.6%	32	25.8%	55	44.4%	19	15.3%	11	8.9%	2.05	124
C	2	1.9%	20	19.2%	36	34.6%	24	23.1%	22	21.2%	1.58	104
D					6	27.3%	8	36.4%	8	36.4%	.95	22
F			1	7.7%	5	38.5%	2	15.4%	5	38.5%	1.20	1

For all students who were Freshmen or Sophomores when they took 0631, including students who were not in GC while taking 0631

Table 15: Average Math 1031 Grade and Math 1031 Pass Rates by GC 0625 Grade (for students whose last preparatory math course was 0625)

0625 grade	% passing Math 1031	Mean grade	Std Deviation	Valid N
A	70%	1.95	1.00	N=50
B	46%	1.30	1.06	N=35
C	45%	1.17	.95	N=22
D or F	14%	.57	.79	N=7

Table 16: Average Math 1051 Grade and Math 1051 Pass Rates by GC 0625 Grade (for students whose last preparatory math course was 0625)

0625 grade	% passing Math 1051	Mean grade	Std Deviation	Valid N
A	90%	2.47	1.00	N=30
B	53%	1.47	1.12	N=19
C, D or F	25%	.79	.96	N=8

passing defined as grade of C- or better in the course

As Tables 17 and 18 below show, when controlling for 0631 grade there appears to be no marked difference in Math 1031/1051 grades between students who were in GC at the time of their last preparatory math and those who were not.

Table 17: Average Math 1031 Grade by GC 0631 Grade and GC/Non-GC Student Status (status at time of last GC Math)

0631 Grade	GC Freshman or Sophomore at time of last GC Math			Non-GC Freshman or Sophomore at time of last GC Math		
	Mean Math 1031 Grade	Std Deviation	Total N	Mean Math 1031 Grade	Std Deviation	Total N
A	2.73	.92	N=103	2.65	1.05	N=67
B	2.04	.85	N=181	2.13	.99	N=84
C	1.48	.93	N=144	1.56	.76	N=49
D	1.12	.98	N=37	1.71	1.11	N=7
F	.88	.93	N=17	.00	--	N=1

Table 18: Average Math 1051 Grade by GC 0631 Grade and GC/Non-GC Student Status (status at time of last GC Math)

GC 0631 Grade	GC/Non-GC Student Status	Average Math 1051 Grade
A	GC	2.47
A	Non-GC	2.65
B	GC	1.47
B	Non-GC	2.13
C	GC	1.17
C	Non-GC	1.56
D	GC	.57
D	Non-GC	1.71
F	GC	.57
F	Non-GC	.00

Grade	GC Freshman or Sophomore at time of last GC Math			GC Freshman or Sophomore at time of last GC Math		
	Mean Math 1051 grade	Std Deviation	Total N	Mean Math 1051 grade	Std Deviation	Total N
A	2.97	1.00	N=86	2.77	1.14	N=35
B	2.07	1.01	N=97	2.00	.96	N=27
C	1.59	1.06	N=83	1.56	1.21	N=21
D	.90	.85	N=20	1.50	.71	N=2
F	1.31	1.08	N=12	.00	--	N=1

Relationship Between GC Math History and Grades in College Algebra and Precalculus

In Table 10 above, it is evident that pass rates in non-GC MT courses are related to preparatory math history. In order to further examine this relationship, course grades between Preparatory Math History (PMH) groups were compared for the two most frequent non-GC MT courses: Math 1031 and Math 1051. Course grade descriptive statistics for these groups can be found in the tables below. Both students who were in GC and those who were not in GC at the time of their last preparatory math course are included in this analysis.

Table 19: Percent Passing Math 1031 by Preparatory Math History Group for Students Taking Math 1031 as Their First Subsequent MT Course

Preparatory Math History Group	% passing Math 1031	Mean	Std Deviation	N
Took only 0621	40%	1.40	1.43	N=10
Took 0621 and 0625	48%	1.44	1.38	N=21
Took 0621, 0625, and 0631	64%	1.77	1.03	N=123
Took only 0625	59%	1.59	.99	N=100
Took 0625 and 0631	72%	2.02	1.06	N=448
Took only 0631	72%	2.11	1.10	N=229

For all students who were Freshmen or Sophomores when they took 0631, including students who were not in GC while taking 0631. Passing defined as a grade of C- or better in the course.

Table 20: Percent Passing Math 1051 by Preparatory Math History Group for Students Taking Math 1051 as Their First Subsequent MT Course

Preparatory Math History Group	% passing Math 1051	Mean	Std Deviation	N
Took only 0621	50%	1.25	.96	N=4
Took 0621 and 0625	100%	2.87	1.02	N=5
Took 0621, 0625, and 0631	46%	1.50	1.16	N=50
Took only 0625	66%	1.81	1.17	N=53
Took 0625 and 0631	73%	2.18	1.19	N=215
Took only 0631	76%	2.17	1.16	N=153

For all students who were Freshmen or Sophomores when they took 0631, including students who were not in GC while taking 0631. Passing defined as a grade of C- or better in the course.

Upon visual inspection of the above tables, it seems apparent that preparatory math history is related to grades in 1031 and 1051. To test this relationship, a regression model was used to examine differences in Math 1031 and Math 1051 grades between students who completed at most 0625, students who took 0631 only, students who took 0631 but began in 0625, and students who took 0631 but began in 0621. Preparatory Math History group alone accounted for a significant portion of variance in 1031 and 1051 grade (about 3% of the variance in course grade for each course (1031 and 1051) was explained by Preparatory Math History group). However, some of this relationship could be

attributable to grade earned in last preparatory math as well as performance in the term in which 1031/1051 was taken, since preparatory math grades are related to Math 1031/1051 grades ($r=.45$ for Math 1031; $r=.49$ for Math 1051), and adjusted term GPA for the term in which 1031/1051 was taken is related to 1031/1051 grade ($r=.37$ for Math 1031; $r=.31$ for Math 1051). In order to control for these factors, these two variables were entered into the regression model first, followed by Preparatory Math History group. When the other variables were accounted for, Preparatory Math History group still explained an additional (and statistically significant) proportion of variance in Math 1031 (additional 3% of the variance) and Math 1051 (additional 3% of variance) course grade.

It thus appears that, regardless of students' achievement in other courses, students who only took 0631 or took 0625 and 0631 received better grades in College Algebra and Precalculus than students who only took 0625 or students who took 0631 but started out in 0621. These results suggest that progressing through the sequence of preparatory math courses did not fully remedy students' difficulty with math. Students who started out in 0625 or 0621 did tend to receive lower grades in 0631 than students who took only 0631, a fact which alone suggests that these students may have had more difficulty in subsequent math courses. But, accounting for this difference does not completely "explain" why students with a weaker pre-college math background (i.e. needed to take 0621) but who nevertheless progressed through 0631 still tended to struggle (relative to students with a stronger pre-college math background) in College Algebra and Precalculus. In an optimal preparatory situation, these differences should not remain when controlling for preparatory math course performance. The fact that students who only went as far as 0625 received lower grades in College Algebra (Math 1031) than students who took 0631, suggests that some effective "remediation" is occurring. But, this difference was not evident for Precalculus (Math 1051) performance, where grades were not significantly different between students who had only gone as far as 0625 and students who had taken 0631 as well as 0621 and 0625.

Comparison of College Algebra, Precalculus, Intro Philosophy and Intro Statistics Grades Between Students Who Had Taken GC Math and Those Who Had Not

To further examine group differences in non-GC MT course performance, course records for Philosophy 1001, Statistics 1001, Math 1031, and Math 1051 were divided into five groups (referred to as "Math Group" in the remainder of the report) comprised of: students who had taken preparatory math while in GC (1,045 records), students who had taken preparatory math while not in GC (395 records), CLA Freshman and Sophomores who had not taken preparatory math (6,383 records), CLA students who had started in GC but had not taken preparatory math (i.e. GC transfer students: 160 records), and GC students who had not taken preparatory math (342 records).

Course grades between these groups were then compared for Philosophy 1001, Statistics 1001, Math 1031, and Math 1051. Descriptive statistics for the grades that students in the groups earned in these courses are shown in the two tables below. Course grades between the groups for Math 1031 and 1051 were further examined using Analysis of Covariance.

Table 21: Descriptive Statistics for Math 1031 and Math 1051 Grade by Math Group

Math Group	Math 1031: College Algebra				Math 1051: Precalculus I			
	% passing Math 1031	Mean grade	SD	N	% passing Math 1051	Mean grade	SD	N
GC Freshman or Sophomore at time of last preparatory math	66%	1.85	1.07	583	70%	2.05	1.19	351
Non-GC Freshman or Sophomore at time of last preparatory math	72%	2.05	1.07	230	72%	2.16	1.21	94
CLA Freshman and Sophomores-did not take preparatory math	77%	2.19	1.13	2241	77%	2.20	1.20	1550
CLA student-began in GC but did not take preparatory math	56%	1.69	1.30	45	78%	2.00	1.12	9
GC student-did not take preparatory math	66%	1.96	1.26	160	74%	2.18	1.23	144

passing defined as grade of C- or better in the course

Table 22: Descriptive Statistics for Philosophy 1001 and Statistics 1001 Grade by Math Group

	Philosophy 1001:Introduction to Logic				Statistics 1001:Introduction to Ideas of Statistics			
	% passing Phil. 1001	Mean grade	SD	N	% passing Stat. 1001	Mean grade	SD	N
GC Freshman or Sophomore at time of last preparatory math	52%	1.78	1.27	46	78%	1.93	.93	65
Non-GC Freshman or Sophomore at time of last preparatory math	59%	1.69	1.16	27	82%	2.37	1.12	44
CLA Freshman and Sophomores-did not take preparatory math	81%	2.53	1.24	1793	91%	2.74	1.02	799
CLA student-began in GC but did not take preparatory math	59%	1.90	1.44	69	86%	2.58	1.00	37
GC student-did not take preparatory math	67%	2.14	1.24	27	100%	2.55	.56	11

passing defined as grade of C- or better in the course

In all of the courses above, students who began in preparatory math tended to receive lower course grades than CLA students who did not begin in preparatory math (or begin their academic career in GC). This difference in grades is more marked for Philosophy 1001 and Statistics 1001. This is probably due to the fact that the students who began in preparatory math but only went as far as 0621 or 0625 were more likely to opt for these courses as opposed to Math 1031 or 1051: 66% of the group who began in preparatory math and took Philosophy 1001 or Statistics 1001 had taken GC 0631, and 85% of the group who began in preparatory math and took Math 1031 or 1051 had taken GC 0631. Furthermore, students who only took 0631 were somewhat less likely to choose Philosophy 1001 or Statistics 1001 as their first non-GC MT course than students who took 0631 but began in 0621 or 0625.

Students who began in GC, but did not take GC Math received slightly higher grades in these non-GC MT courses than students who began in GC and took preparatory math. It is interesting that, of students who began in GC but did not take preparatory math, those who had taken these MT courses after transferring to CLA appeared to have grades slightly lower than the students who were still in GC (except in Math 1051). These findings suggest that, a). the students who slip through the cracks and do not take GC Math are doing so appropriately, and b). Perhaps it is more advantageous that these students take their non-GC MT course while still in GC. The number of observations upon which conclusion "b" is based are very small however, and whether these differences are meaningful is dubious.

If remediation were completely successful, one would expect that there would be little difference in non-GC MT course grades between students who had gone through preparatory math and students who had not (and had not needed to); after all, the goal of remediation is to "correct fault or difficulty" through some intermediary experience which after completion enables students (with a prior disadvantage) to compete on a more equitable footing. But, fairly marked differences in non-GC MT course grades were evident between students who had taken preparatory math and students who had not. This suggests that other factors are still at work negatively impacting grades in non-GC MT courses for students who required math remediation; Some of these "other factors" presumably are students' preparatory math course grades, current level of college achievement and pre-college math preparation. In order to account for these influences, Analysis of Covariance was used to examine differences in non-GC MT course grade between the groups of students in the above tables when controlling for pre-college math background and college performance. Analyses were conducted only for Math 1031 and Math 1051, since these were the courses taken most frequently by the preparatory math students. Analyses were first conducted with *all* preparatory math students (Full Sample Analysis). Later, to account for preparatory math course grade, only students who received a grade of C or better in 0631 were included in the analysis (Restricted Sample Analysis); a grade of C or better in GC 0631 is one of the pre-requisites for Math 1031 and Math 1051.

For all models, the following covariates were entered: term GPA and credits for the term in which 1031/1051 was taken (not including 1031/1051 grade and credits), ACT Math score, and High School Math GPA. In both the Full Sample and Restricted Sample analyses, all of the covariates accounted for a significant proportion of the overall variance in course grade. Overall, for 1031 grade, term GPA and term credits accounted for 18% of the variance in 1031 grade, and ACT Math and High School Math GPA accounted for an additional 12% of the variance. For 1051 grade, term GPA and term credits accounted for 18% of the variance in 1051 grade, and ACT Math and High School Math GPA accounted for an additional 8% of the variance. This relationship between the covariates and 1031/1051 course grade seemed to be operating for all Math Groups.

Tables 23 and 24 below show results of the Full Sample Analysis, and Tables 25 and 26 present results of the Restricted Sample Analysis. First, some tips on how to interpret the results in these tables will be mentioned. In the tables are displayed statistics pertaining to both the *actual* mean grades (column 6-9) and the *model predicted* mean grades (columns 2-5) for Math 1031/1051. The model predicted means are what result when controlling for the influence of the covariates. These means (in column 2) can be interpreted as the (hypothetical) average grade (for each group) when the current level of college achievement and pre-college math preparation for each group is comparable to the current level of college achievement and pre-college math preparation for General College students who took preparatory math. Column 4 and 5 display the confidence intervals for the model predicted means, and Column 8 and 9 display the confidence intervals for the actual means. Confidence intervals describe whether two means can be considered significantly different from one another. When there is no or little overlap between the confidence intervals of any two groups, there groups can be considered to differ significantly on the dependant variable (which in this case is 1031 or 1051 course grade).

As is evident in the tables below, CLA Freshman and Sophomores who (supposedly) did not need preparatory math received grades significantly higher than students who had taken preparatory math (column 6). If students had met the pre-requisite for 1031/1051 (i.e. grade of C or better in GC 0631), this difference still remains for College Algebra (Math 1031), but not for Precalculus (Math 1051). Column 2 shows that *if* CLA Freshman and Sophomores who (supposedly) did not need preparatory math *had* a covariate profile suggestive of the need for preparatory math, they would receive 1031/1051 grades significantly lower than students who had taken preparatory math. This is indirect evidence for the effectiveness of preparatory math; indirect because it is based on model predicted values.

Table 23: Mean Grade in Math 1031 (College Algebra) by Math Group: Adjusted (for covariates) and Unadjusted Means (Full Sample Analysis)

Math Group	Statistics Adjusted for Covariates				Unadjusted Statistics				N
	Mean ^a	Std. Error	95% Confidence Interval		mean	Std. Error	95% Confidence Interval		
			Lower Bound	Upper Bound			Lower Bound	Upper Bound	
GC Freshman or Sophomore at time of last preparatory math	1.86	.040	1.78	1.94	1.86	.048	1.76	1.95	511
Non-GC Freshman or Sophomore at time of last preparatory math	1.88	.074	1.73	2.02	1.96	.086	1.79	2.13	159
CLA Freshman or Sophomore-did not take preparatory math	1.59	.035	1.52	1.66	2.21	.025	2.16	2.26	1881
Began in GC but did not take preparatory math	1.73	.079	1.57	1.88	1.99	.084	1.82	2.15	169

a Evaluated at mean values of the covariates for GC Students who started out in GC Math: term GPA (not including 1031 grade) = 2.76, term credits (not including 1031 credit) = 8.85, ACT math = 19.53, high school math GPA = 2.35.

Table 24: Mean Grade in Math 1051 (Precalculus I) by Math Group: Adjusted (for covariates) and Unadjusted Means (Full Sample Analysis)

Math Group	Statistics Adjusted for Covariates			Unadjusted Statistics			N
	Mean ^a	Std. Error	95% Confidence	mean	Std. Error	95% Confidence	

			Interval				Interval		
			Lower Bound	Upper Bound			Lower Bound	Upper Bound	
GC Freshman or Sophomore at time of last preparatory math	2.07	.057	1.96	2.18	2.07	.066	1.94	2.20	312
Non-GC Freshman or Sophomore at time of last preparatory math	2.15	.129	1.90	2.40	2.16	.149	1.86	2.45	62
CLA Freshman or Sophomore-did not take preparatory math	1.74	.045	1.65	1.83	2.24	.032	2.18	2.31	1296
Began in GC but did not take preparatory math	1.85	.089	1.67	2.02	2.16	.100	1.99	2.38	138

a Evaluated at mean values of the covariates for GC Students who started out in GC Math: term GPA (not including 1051 grade) = 2.71, term credits (not including 1051 credit) = 8.95, high school math GPA = 2.37, ACT math = 20.28.

Table 25: Mean Grade in Math 1031 (College Algebra) by Math Group: Adjusted (for covariates) and Unadjusted Means (Restricted Sample Analysis)

Math Group	Statistics Adjusted for Covariates				Unadjusted Statistics				N
	Mean ^a	Std. Error	95% Confidence Interval		mean	Std. Error	95% Confidence Interval		
			Lower Bound	Upper Bound			Lower Bound	Upper Bound	
GC Freshman or Sophomore at time of last preparatory math	2.07	.047	1.98	2.16	2.03	.056	1.92	2.14	376
Non-GC Freshman or Sophomore at time of last preparatory math	2.05	.079	1.90	2.21	2.07	.093	1.88	2.25	137
CLA Freshman or Sophomore-did not take preparatory math	1.71	.034	1.65	1.78	2.21	.025	2.16	2.26	1881
Began in GC but did not take preparatory math	1.84	.077	1.69	2.00	1.99	.083	1.83	2.15	169

a Evaluated at mean values of the covariates for GC Students who received a C or better in GC 0631: term GPA (not including 1031 grade) = 2.95, term credits (not including 1031 credit) = 8.90, high school math GPA = 2.38, ACT math = 19.71.

Table 26: Mean Grade in Math 1051 (Precalculus I) by Math Group: Adjusted (for covariates) and Unadjusted Means (Restricted Sample Analysis)

Math Group	Statistics Adjusted for Covariates				Unadjusted Statistics				N
	Mean ^a	Std. Error	95% Confidence Interval		mean	Std. Error	95% Confidence Interval		
			Lower Bound	Upper Bound			Lower Bound	Upper Bound	
GC Freshman or Sophomore at time of last preparatory math	2.23	.065	2.101	2.357	2.23	.076	2.081	2.379	235
Non-GC Freshman or Sophomore at time of last preparatory math	2.28	.138	2.011	2.551	2.27	.158	1.961	2.582	54
CLA Freshman or Sophomore-did not take preparatory math	1.79	.045	1.706	1.883	2.24	.032	2.179	2.306	1296
Began in GC but did not take preparatory math	1.90	.089	1.722	2.070	2.18	.099	1.989	2.378	138

a Evaluated at mean values of the covariates for GC Students who received a C or better in GC 0631: term GPA (not including 1051 grade) = 2.80, term credits (not including 1051 credit) = 8.94, high school math GPA = 2.39, ACT math = 20.32

Analyses revealed that preparatory math students still seemed to be plagued by their pre-college math preparation, since ACT Math and High School Math GPA still explained a significant portion of the variance in 1031/1051 grade above and beyond current college performance. But, nonetheless, if preparatory math students met the pre-requisite

for 1031/1051 by receiving a grade of C or better in 0631, they would stand a better chance of receiving grades comparable to non-"remediated" CLA students. When controlling only for college performance, students who had taken preparatory math (regardless of whether they met the 1031/1051 pre-requisites) still performed less well in Math 1031/1051 than CLA students who did not take preparatory math. But, when controlling for pre-college indicators of math achievement, preparatory math students appeared (according to the model) to outperform the non-"remediated" CLA students in Math 1031/1051. However, when considering only preparatory math students who had met the pre-requisite for Math 1031/1051 (i.e. received a grade of C or better in 0631), controlling only for students' current level of college performance removed the significant difference in College Algebra grades between preparatory math students and non-"remediated" CLA students. No control variables needed to be entered when examining Precalculus grades: Preparatory math students who met the Precalculus requirement received actual grades similar to non-"remediated" CLA students.

Finally, to make the results of the above analyses less esoteric, some concrete, descriptive data will be presented. As stated earlier, the mean differences in column 2 of the tables above provides indirect evidence for the effectiveness of preparatory math; indirect because it is based on model predicted values. However, direct evidence can be brought to bear upon the value of preparatory math. First, a subgroup was extracted from the CLA students not having taken preparatory math that had current level of college achievement and pre-college math preparation similar to the group of students who had taken preparatory math. The students from this subgroup who had taken Math 1031 (N=365: mean ACT Math=19.74; High school math GPA=2.38; adjusted term GPA=2.71) had an average Math 1031 grade of 1.66 (SD=1.05). The students from this subgroup who had taken Math 1051 (N=211: mean ACT Math=20.9; High school math GPA=2.45; adjusted term GPA=2.68) had an average Math 1051 grade of 1.81 (SD=1.08). In both cases, average Math 1031/1051 grades are very similar to the model predicted values in Tables 23 through 27.

Second, recall the data that were presented in Tables 13 and 14 earlier in this report displaying Math 1031/1051 grades by 0631 grade. The group of preparatory math students who received A's or B's in GC 0631 received actual 1031/1051 grades comparable to CLA students who did not take preparatory math; This group of students had an average grade of 2.32 (SD=.97, N=453) in 1031, and 2.48 (SD=1.10, N=245) in 1051. The small percentage of students who only went as far as 0625 and took 1031 did not fare as well; Students who received an A in 0625 had an average Math 1031 grade of 1.95 (SD=1.00, N=50). But, the very small group of students who stopped at 0625, received an A in the class, and took 1051, had an average 1051 grade comparable to non-"remediated" CLA students (mean grade=2.47, SD=1.00, N=30). This data, in conjunction with the results in Tables 23-26, support the validity of the preparatory math pre-requisite as a "gate-keeper" for College Algebra and Precalculus enrollment.

Conclusions

Some important conclusions to be drawn from this report are as follows: First, most General College students appeared to be fulfilling their Mathematical Thinking requirement in a reasonably appropriate manner. If they had not progressed through the full preparatory math sequence, they were more likely to opt for Mathematical Thinking courses offered through General College. If they had completed Intermediate Algebra II, the terminal point of the preparatory mathematics sequence, they were more likely to enroll in College Algebra or Pre-calculus. Second, support was found for the validity of the preparatory mathematics pre-requisite as a "gate-keeper" for College Algebra and Pre-calculus enrollment. Students who received a grade of C or better in Intermediate Algebra II received College Algebra/Pre-calculus grades fairly comparable to those earned by their classmates who did not take preparatory mathematics; however, there was evidence to suggest that students should earn at least a B in Intermediate Algebra II in order to be fully competitive in College Algebra/Pre-calculus. Third, students who slip through the cracks and do not take preparatory mathematics appeared to be doing so appropriately. They performed quite competitively in college-level math courses for which Intermediate Algebra II was a prerequisite. Finally, though preparatory mathematics courses did appear to have had a positive effect on preparing students for future college-level mathematics courses, there was some evidence that progressing through these courses did not fully remedy students' difficulty with mathematics. However, this may be a moot point given a). that, regardless, students appear to be fulfilling their Mathematical Thinking requirement, and b). the high probability that many GC students do not choose mathematically intensive majors.

These conclusions, however, are based on the quarter system structure. Whether conclusions hold within the new semester system structure remains to be tested. This present analysis provides some important baseline information against which to compare the utilization, functionality, and effectiveness of the *semester*-based preparatory

mathematics program.

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