A Longitudinal Study of the Effectiveness of Traditional and Hybrid Online Instruction in Preparatory Calculus

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Introduction

In the Spring 2012 semester, UC Merced was the first campus of the University of California System to offer a course section through UC's online instructional program. The course was Preparatory Calculus, Math 005. Based on a successful initial experience, all subsequent sections of Math 005 were offered using the combination of two-hour discussion sessions and online coursework. This paper revisits the initial assessment that was based on faculty judgment, grade distributions and similar measures in the first semester offered. The paper extends analysis across a longer period and to the quality of preparation as measured by performance in the subsequent mathematics courses, Math 011 Calculus 1 (required of economics, management, cognitive sciences and other Social Sciences, Humanities and Arts majors), and Math 021 Calculus 1 for Physical Sciences and Engineering majors. Comparing grade distributions in the initial term of offering was a weaker evaluation standard, especially when faculty self-selected to teach a new type of course section that was the focus of considerable interest, and were well aware of the special assessment and the potential impact (Hawthorne Effect). While this paper does not rise to the research design rigor of truly randomized design with pre- and post-tests (Bowen et al., 2013) the results confirm the vast majority of research showing no significant academic performance difference. See Ramage (2002) for an excellent review of the research.

This report will compare:

1. Traditional and hybrid Math 005 course grades with comparisons by race/ethnicity, Pell eligibility, first-generation college status, language spoken in home, and gender.
2. Performance in Calculus 1 (Math 011 and Math 021) for students who took Preparatory Calculus (Math 005) as a hybrid or traditional course.
3. Performance in traditional and hybrid Preparatory Calculus (Math 005) by math ability as measured by SAT Mathematics score.
4. Subsequent performance in Calculus 1 (Math 011 and Math 021) for students of different mathematical abilities (measured by SAT Mathematics) who took Preparatory Calculus (Math 005) as a hybrid or traditional course.

Results

Table 1: UC Online Course Evaluation Standard – Comparison of Letter Grade Distributions

Overall, there has been improvement in letter grades in hybrid course sections after the switch to hybrid courses in fall of 2012, especially more B grades and fewer C's and F's. Overall, 8% more students earned a C or higher grade in the hybrid course.

The overall results were also true for African-Americans, Asians, Hispanics/Latinos, students of two or more races, and white students. In contrast, nonresident/alien students did better in the traditional course. There is no obvious reason for the difference, but there were only 26 students in that group and different outcomes for a few students could have changed the result.

Pell eligible students and students who were not Pell eligible performed better in the hybrid course.

First-generation college students and students who were not first-generation college performed better in the hybrid course.

The hybrid course advantage was not as clear for students from homes where the language spoken was not English. They were as likely to earn a C or higher grade and more likely to earn a B grade, so there was an advantage, but the advantage was less obvious than for students from English speaking homes or homes where English and another language was spoken.

Males and females performed better in the hybrid preparatory course and the pattern of difference by letter grade was very similar.

Given that students in the hybrid course were consistently more successful and that the relative pattern of grades was consistent across a variety of demographic characteristics, demographic variables will not be considered further in this paper.

Table 2: Performance in First Calculus Course for Hybrid and Traditional Preparatory Calculus Students

A better, more valid comparison of hybrid and traditional Preparatory Calculus courses is the subsequent performance of students in the Calculus course for which the preparatory course was a prerequisite. The comparisons made in this study do not clearly support either preparatory course instructional type. Overall, hybrid preparatory students were more likely to earn a C or higher grade in Math 011 Calculus 1 for Social Sciences, and were equally likely to earn a C or higher grade in Math 021 Calculus 1 for Physical Sciences and Engineering. But, students who earned an A in the hybrid preparatory course were less likely to earn an A in either calculus course than were students who earned an A in the traditionally taught preparatory course. (Why that might be the case is considered in the observations section at the end.)

Table 3: Math Ability and Performance in Hybrid or Traditional Preparatory Calculus Courses

Students with SAT Math scores in the middle 50% and students with SAT Math scores in the upper 25% were equally likely to earn a C or higher grade in either type of Preparatory Calculus. Students with Math scores in the bottom 25% were more likely to earn a C or higher in the hybrid preparatory course and were more likely to earn a B letter grade. Students in the middle 50% were more likely to earn A's and B's and less likely to earn C grades in the hybrid course.

Students with SAT Math scores in the upper 25% did as well in either preparatory course. Overall, the hybrid course was better for students in the lower 75% of the SAT Math distribution (middle 50% and bottom 25%) and as good as the traditional course for students in the top 25%. As was stated earlier in the paper, a better measure of learning is performance in the subsequent calculus course and that will be considered next.

Table 4: Math Ability and Performance in Calculus by Traditional or Hybrid Preparatory Calculus Course Using Grade Points and Letter Grades

As expected from results cited earlier, the mean grade points were higher in the hybrid course for students from the lower 25% of the SAT Math distribution and slightly higher in the hybrid course for the other 75%.

When performance in the subsequent calculus course was compared for hybrid and traditional preparatory students, students from the upper 25% of the SAT Math distribution had higher mean grade points in Math 011 and equal grade points in Math 021. For the middle 50% of the SAT Math distribution mean grade points were similar in both Math 011 and Math 021. The lower 25% of the SAT Math distribution had mean grade points in Math 011 that were very similar but slightly lower in Math 021 for students prepared in the hybrid course.

Performance results can be seen in more detail in the letter grade tables. When performance in calculus based on performance in preparatory calculus was considered for those in the bottom 25% of the SAT Math distribution, the results were mixed. Overall, students in Calculus 1 Math 011 were more likely to earn a C or higher grade but those in Calculus 1 for Physical Sciences and Engineering, Math 021) were less likely to earn a C or higher grade. For students in Math 011, the difference for students who had earned an A in hybrid or traditional Preparatory Calculus (Math 005) was troubling. Thirty-eight percent of students who earned an A in traditional Preparatory Calculus earned an A in Calculus 1. Only six percent of those with an A earned in the hybrid preparatory course earned an A in Calculus 1. That difference was offset among all successful outcomes by a greater likelihood of B and C letter grades in Calculus 1. In other words, the hybrid preparatory course students were much less likely to earn an A but much more likely to earn a B and more likely to earn a C in Calculus 1 so that overall success rates were higher for the hybrid version.

Hybrid preparatory students in the bottom 25% of SAT Math scores did not do as well in Calculus 1 for Physical Sciences and Engineering. (Please note that the subsequent calculus course performance comparisons were made only for those in the hybrid and traditional preparatory courses who then took calculus. Many preparatory course students did not subsequently enroll in calculus.) The tables at the right in Table 4 display the preparatory calculus letter grade to calculus letter grade distributions. For example, 94% of students who earned A's in the traditionally taught preparatory course, earned a C or higher grade in Math 011 and 100% earned a C or higher in Math 021. For the students who earned A's in the hybrid course, 100% earned a C or higher in Math 011 and 75% earned a C or higher in Math 021.

Preparatory Calculus students in the middle 50% on SAT Math scores were more likely to be successful in Math 011 if they had been in a hybrid course and were equally likely to be

successful if in a traditional course. As was true for the lower 25% students, students with A's in the preparatory course were less likely to earn A's in Calculus 1 if they had been in the hybrid course.

Students in the top quarter of SAT Math scores were more likely to be successful in both calculus courses if they had completed the hybrid preparatory course than the traditional preparatory course. But, even for students in the top quarter of SAT Math scores, students with A's in the hybrid preparatory course were less likely to earn an A in the calculus course than were students who earned A's in the traditional Preparatory Calculus course.

Table 5: Likelihood of Repeating Preparatory Calculus by Instructional Method

Many University constituencies are concerned about the inefficiency, cost and impact to students associated with repeating classes. Because the shift from traditional to hybrid instruction in Math 005 was universal in the Fall of 2012 and has continued to the current date, it is not possible to adequately control all variables that might be associated with course repetition. For example, there may be students who did poorly in Math 005 as a freshman who put off retaking the course until their senior year. They were more likely to have reached that senior year if they took the traditional Math 005 course in the Spring of 2012 or before and may not have reached senior year if they took the hybrid course. We would therefore expect the traditional Math 005 course to have a higher repeat rate, but the observed rate is over twice the rate for the hybrid Math 005 course. While it is mathematically possible for the hybrid Math 005 course to ultimately exhibit a repeat rate higher than that observed for the traditional Math 005 course, it is more likely that the hybrid course repeat rate will be lower than the traditional Math 005 course repeat rate.

Observations

Math 005, Preparatory Calculus, is an excellent proxy for traditional versus hybrid course instructional methods discussions. It was developed through a System-wide initiative, it has large enrollments over several years before and after the switch to hybrid instruction, and it is a prerequisite course for many students needing to start a required calculus sequence. Preparation for the first calculus course is more important than grade earned in the preparatory course and comparing subsequent performance by method of preparatory instruction is more important than comparing traditional or hybrid grades in the preparatory course. In other words, the distribution of grades in the following math course is more important than the distribution in the preceding hybrid or traditional course in spite of simple course grade comparisons by demographic variables being the norm for UC (see Appendix).

Overall, there is no reason to be concerned that learning in the hybrid Preparatory Calculus course is less than in the traditional course that preceded it. There were most often no differences in subsequent performance and, when there were differences, they almost always favored the hybrid course.

Based on course grades, hybrid instruction in Preparatory Calculus more often produced successful outcomes in the preparatory course overall and across all demographic categories except for those from families that spoke a language other than English.

Performance in the Math 011 calculus course was better overall for students from the hybrid course and equivalent for those in the physical sciences and engineering calculus course. There was however a shift in subsequent A letter grades for students who had earned A's in the preparatory course. At several points in the analysis, attention was drawn to finding that A letter grade students in the preparatory course were less likely to earn A's in the following calculus course if the preparatory course had used hybrid instruction. That result could be a robust finding about outstanding performance in traditional courses because of increased time or extent of comprehension when instruction was not self-paced, or it could reflect a change in Mathematics' grading practices, or another phenomenon entirely. Except for the mix of instructional methods in Spring 2012, all subsequent preparatory courses were hybrid. For example, if Math awarded fewer A's after spring semester 2012, then the exhibited pattern would be expected even if there were no real difference.

Whether the ability to benefit from a change to hybrid instruction is associated with ability in a disciplinary area is an important question. These results are especially useful because there is a good measure of prior disciplinary ability, SAT Math, which was not used in placing students into the preparatory course. The findings were mixed. For students with SAT Math scores in the bottom 25% for this group (SAT Math 200-460), performance in Calculus 1 for social sciences was generally better, but worse in Calculus 1 for Physical Sciences and Engineering. Students in the middle 50% (SAT Math 470-580), did better in Calculus 1 for social sciences and equally well in Calculus 1 for Physical Sciences and Engineering. Hybrid preparatory students in the top 25% (SAT Math of 590-800) performed better in both Calculus 1 for social sciences and Calculus 1 for Physical Sciences and Engineering.

Please note that the analyses in this paper are pedagogically focused. The analyses are not concerned about other comparisons that could be made about facility use, instructional costs, student opinions, scheduling advantages, faculty preferences, etc. Consistent with the large majority of the more rigorous research about learning in higher education comparing hybrid online or traditional instruction, academic outcomes are equivalent (Utts et al., 2003; Bowen et al., 2013).

References

Bowen, W. G., Chingos, M. W., Lack, K. A. & Nygren, T. I. (2013). Online learning in higher education, EducationNext, *13*(2), 1-4, *EducationNext.org*.

Ramage, T. R. (2002). "The "No Significant Difference" Phenomenon: A Literature Review". *Dr. Thomas R. Ramage Scholarship.* Paper 1.

Utts, J., Sommer, B., Acredolo, C., Maher, M. W., & Matthews, H. R. (2003). A study comparing traditional and hybrid Internet-based instruction in introductory statistics classes, *11*(3), 1-7. *Journal of Statistical Education*.

Appendix

Supplemental Questions for Distance or Blended Course Approval Requests Merced Division of the Academic Senate Undergraduate Council

Supplemental Questions for Distance or Blended Course Approval Requests
Merced Division of the Academic Senate
Undergraduate Council

The following questions are to be answered by the instructor proposing the course, to be submitted along with the course approval form and syllabus.

Instructor Name: _____

School, Course Title and Number _____

1. Will this course be delivered completely through distance technologies, or will it be a hybrid, with a significant component (at least 1/3 of contact hours) in person and a significant component (at least 1/3) delivered by distance?

2. What modes of instruction will be used, particularly those specific to technologically mediated instruction (e.g., moderated discussion lists, email, chat rooms)?

3. The course must at least provide an equivalent educational experience for students. What specific pedagogical advantages does the technologically mediated format offer? If none, how will specific potential detriments be countered? Specifically, if this is a large introductory course, especially one that serves as a pre-requisite for other courses, how will traditionally educationally disadvantaged students be impacted, and how will any negative impacts be mitigated? How will the efficacy of the course be assessed, including assessment of "student learning outcomes," disaggregated by demographic sub-groups if possible (per WASC requirements).

4. Studies of distance learning show that students take best advantage of distance learning if the course is structured so as to develop cohorts of learners. How, if at all, will the course facilitate cohort building?

5. How would this way of delivering the course change modes of learning (e.g., auditory or tactile) and affect learning experiences?

6. What is the nature of instructor involvement in the proposed alternative mode of instruction? What are the means by which the instructor will foster learning, and how will the instructor be available for consultation?

7. How will student progress be monitored? Describe graded activities mediated through technology and how materials will be handled to ensure that students receive credit only for their own work. (If the course does not include the required in-class final examination, a variance request for the exemption of this requirement must be submitted simultaneously.)

8. Is specific technical or pedagogical expertise (on the part of the student or instructor) necessary for this course? If so, what? Does the proposal fully recognize the amount of faculty time that will be required to develop, train for, and deliver the proposed course or program of instruction?

9. What specific technical support does the department have available for instructors and students? What plans are there for malfunction, disruption, or unavailability of technical support?

10. In the case of distance learning courses offered collaboratively between campuses, what are the specific responsibilities of instructors on this campus? How will coordination be maintained between campuses, and who will be responsible on this campus for consultation with students?

Table 1: UC Online Course Evaluation Standard - Comparison of Letter Grade Distributions

	Grade	Math 005 - Traditional	Math 005 - Hybrid	Math 005 - Traditional	Math 005 - Hybrid
Overall					
	A	12%	15%	349	403
	B	29%	**38%**	867	1,026
	C	**34%**	29%	1,017	778
	D	10%	9%	294	235
	F	**14%**	8%	430	219
	W	1%	1%	44	32
	C or Higher	74%	**82%**	3,001	2,693
Race / Ethnicity					
African American					
	A	6%	**15%**	16	27
	B	24%	**33%**	61	59
	C	33%	33%	86	58
	D	12%	10%	30	17
	F	**24%**	7%	62	13
	W	1%	2%	3	3
	C or Higher	63%	**81%**	258	177
Asian / Pacific Islander					
	A	14%	**19%**	110	102
	B	31%	**43%**	242	230
	C	**34%**	23%	267	123
	D	9%	8%	69	40
	F	**11%**	6%	90	32
	W	1%	1%	9	3
	C or Higher	79%	**86%**	787	530
Hispanic / Latino					
	A	9%	13%	120	179
	B	27%	**36%**	337	507
	C	**36%**	31%	451	431
	D	11%	9%	135	121
	F	**16%**	10%	204	141
	W	1%	2%	18	21
	C or Higher	72%	**80%**	1,265	1,400

Table 1: UC Online Course Evaluation Standard - Comparison of Letter Grade Distributions

Grade	Math 005 - Traditional	Math 005 - Hybrid	Math 005 - Traditional	Math 005 - Hybrid
Nonresident / Alien (Note Small Group Size of 26)				
A	**27%**	12%	7	15
B	27%	**38%**	7	50
C	27%	25%	7	33
D	12%	**17%**	3	22
F	4%	7%	1	9
W	4%	1%	1	1
C or Higher	**81%**	75%	26	130
Two or More Races				
A	14%	**20%**	9	20
B	**43%**	34%	28	34
C	29%	29%	19	29
D	6%	10%	4	10
F	8%	7%	5	7
W				
C or Higher	86%	83%	65	100
White				
A	15%	18%	74	56
B	34%	**40%**	164	122
C	31%	28%	149	86
D	9%	7%	43	22
F	**10%**	5%	48	15
W	2%	1%	10	4
C or Higher	79%	**87%**	488	305
Pell Eligibility				
Pell Eligible in 1st Term				
A	10%	13%	165	231
B	27%	**37%**	470	648
C	**35%**	30%	599	539
D	11%	9%	184	167
F	**17%**	9%	290	159
W	2%	1%	27	24
C or Higher	71%	**80%**	1,735	1,768

Table 1: UC Online Course Evaluation Standard - Comparison of Letter Grade Distributions

Grade	Math 005 - Traditional	Math 005 - Hybrid	Math 005 - Traditional	Math 005 - Hybrid
Not Pell Eligible in 1st Term				
A	14%	**19%**	183	172
B	31%	**41%**	397	376
C	**33%**	26%	418	238
D	9%	7%	110	68
F	11%	7%	140	60
W	1%	1%	17	8
C or Higher	79%	**85%**	1,265	922
First Generation College (Bachelors)				
1st Generation				
A	10%	13%	181	255
B	27%	**37%**	499	716
C	34%	30%	624	574
D	11%	9%	193	176
F	**16%**	9%	291	182
W	2%	1%	30	23
C or Higher	72%	**80%**	1,818	1,926
Not 1st Generation				
A	14%	**19%**	167	148
B	31%	**40%**	368	308
C	**33%**	27%	393	203
D	9%	8%	101	59
F	**12%**	5%	139	37
W	1%	1%	14	9
C or Higher	79%	**86%**	1,182	764
Language Spoken in Home				
Language in Home not English				
A	13%	15%	94	147
B	28%	**37%**	195	352
C	**38%**	29%	264	279
D	9%	9%	66	85
F	11%	9%	74	87
W	1%	1%	8	11
C or Higher	79%	81%	701	961

Table 1: UC Online Course Evaluation Standard - Comparison of Letter Grade Distributions

Grade	Math 005 - Traditional	Math 005 - Hybrid	Math 005 - Traditional	Math 005 - Hybrid
Language in Home English Only				
A	13%	17%	157	140
B	31%	**39%**	366	326
C	32%	28%	378	239
D	9%	9%	111	72
F	**13%**	7%	159	57
W	2%	1%	23	7
C or Higher	75%	**84%**	1,194	841
Language in Home English and Another Language				
A	8%	**13%**	92	116
B	28%	**39%**	301	344
C	**34%**	29%	370	258
D	11%	9%	115	76
F	**18%**	8%	192	75
W	1%	2%	13	14
C or Higher	70%	**81%**	1,083	883
Sex / Gender				
Female				
A	11%	15%	178	220
B	27%	**36%**	439	518
C	34%	31%	563	440
D	11%	9%	176	130
F	**16%**	8%	258	113
W	2%	1%	25	17
C or Higher	72%	**82%**	1,639	1,438
Male				
A	12%	15%	167	182
B	31%	**40%**	423	499
C	**33%**	27%	450	330
D	9%	8%	117	103
F	**13%**	8%	171	104
W	1%	1%	19	15
C or Higher	77%	**82%**	1,347	1,233

Highlights are > 5%

Table 2: Performance in First Calculus Course for Hybrid and Traditional Preparatory Calculus Students

Advantage (Hybrid - Traditionally Taught): Differences > 10% Highlighted

	Math 011						
Math 005	A	B	C	D	F	W	C or Higher
A	**-19%**	**17%**	7%	0%	-1%	-3%	**5%**
B	-4%	1%	2%	3%	-2%	0%	-1%
C	1%	-4%	4%	6%	-7%	-1%	1%
D	-5%	6%	**-15%**	2%	**17%**	-5%	**-14%**
F							
W							
Total	-1%	6%	3%	1%	-7%	-1%	8%

	Math 021						
Math 005	A	B	C	D	F	W	C or Higher
A	**-15%**	3%	5%	5%	1%	1%	**-7%**
B	0%	**-12%**	**10%**	5%	-1%	-1%	-3%
C	1%	-6%	-2%	5%	-1%	3%	**-7%**
D							
F							
W							
Total	-1%	-3%	5%	3%	-5%	0%	1%

Traditionally Taught Preparatory Calculus Course, Math 005

	Math 011						
Math 005	A	B	C	D	F	W	C or Higher
A	47%	33%	15%	1%	1%	3%	95%
B	11%	29%	44%	8%	8%	0%	84%
C	1%	14%	45%	15%	22%	3%	60%
D	5%	17%	38%	13%	22%	5%	60%
F	0%	16%	23%	26%	35%	0%	40%
W							
Total	11%	22%	38%	11%	15%	2%	71%

	Math 021						
Math 005	A	B	C	D	F	W	C or Higher
A	31%	39%	25%	1%	3%	1%	95%
B	5%	33%	34%	10%	14%	4%	73%
C	1%	14%	35%	14%	32%	3%	50%
D	3%	3%	26%	21%	44%	5%	31%
F	0%	6%	17%	28%	50%	0%	22%
W							
Total	8%	25%	32%	11%	21%	3%	65%

Hybrid Preparatory Calculus Course, Math 005

	Math 011						
Math 005	A	B	C	D	F	W	C or Higher
A	28%	49%	23%	1%	0%	0%	99%
B	7%	31%	46%	10%	5%	1%	83%
C	2%	10%	49%	21%	16%	2%	61%
D	0%	23%	23%	15%	38%	0%	46%
F							
W							
Total	9%	28%	42%	12%	8%	1%	79%

	Math 021						
Math 005	A	B	C	D	F	W	C or Higher
A	16%	42%	30%	6%	4%	2%	88%
B	5%	21%	44%	14%	14%	2%	70%
C	2%	8%	33%	19%	32%	6%	43%
D							
F							
W							
Total	7%	22%	38%	14%	16%	3%	66%

Why are there grades in calculus for students with a grade below C in precalculus? While a grade of C or higher is a prerequisite for the subsequent calculus course, performance can be demonstrated by transfer coursework and some students in a traditionally taught Math 005 repeated Math 005 as a hybrid course.

Math 005 clusters had to be of 10 or more students before percentages are displayed and differences in the table of 10% or more and 5% or more on at the margins are highlighted.

Table 3: Math Ability and Performance in Hybrid or Traditional Preparatory Calculus Courses

Hybrid Course Advantage (Hybrid - Traditional)

		SAT Math*	
Math 005	Lower 25%	Middle 50%	Upper 25%
A	2%	**5%**	4%
B	**14%**	**8%**	-1%
C	-1%	**-10%**	0%
D	-3%	0%	3%
F			
W			
C or Higher	**14%**	2%	3%

Traditionally Taught Preparatory Calculus Course, Math 005

		SAT Math	
Math 005	Lower 25%	Middle 50%	Upper 25%
A	3%	14%	25%
B	18%	33%	41%
C	37%	36%	22%
D	15%	8%	3%
F	24%	8%	7%
W			
C or Higher	58%	83%	88%

Hybrid Preparatory Calculus Course, Math 005

		SAT Math	
Math 005	Lower 25%	Middle 50%	Upper 25%
A	5%	18%	29%
B	32%	41%	40%
C	36%	26%	22%
D	12%	8%	5%
F			
W			
C or Higher	73%	85%	91%

* The lower 25% had SAT Math scores of 200-460.
The middle 50% had SAT Math scores from 470-580.
The upper 25% had SAT Math scores of 590-800.

Table 4: Math Ability and Performance in Calculus by Traditional or Hybrid Precalculus Course Using Grade Points and Letter Grades

	SAT Math Lower Quarter	SAT Math Middle 50%	SAT Math Upper Quarter	Overall
Preparatory Calculus Comparison				
Math 005 Traditional (Grade Points)	**1.5**	2.3	2.7	**2.1**
Math 005 Hybrid (Grade Points)	**2.0**	2.5	2.9	**2.4**

Performance in Calculus Depending on Preparatory Calculus Course Instruction (Analysis Restricted to Those Who Took Math 005)

	SAT Math Lower Quarter	SAT Math Middle 50%	SAT Math Upper Quarter	Overall
Math 011 (Math 005 Traditional)	1.8	2.1	2.4	2.0
Math 011 (Math 005 Hybrid)	1.9	2.1	2.6	2.1
Math 005 Hybrid - Traditional	0.04	0.07	**0.26**	0.06
Math 021 (Math 005 Traditional)	1.5	1.9	2.3	1.9
Math 021 (Math 005 Hybrid)	1.3	1.8	2.3	1.8
Math 005 Hybrid - Traditional	**-0.12**	-0.04	-0.01	-0.04

Grade Points (A=4, A- = 3.7, B+ = 3.3, B=3, B- = 2.7, C+ = 2.3, C=2, C- = 1.7, C+ = 1.3, D=1, D- = 0.7, F=0)

Lower Quarter SAT Math (SAT Math 200-460)

Hybrid Advantage (Hybrid - Traditionally Taught)

	Math 011						
Math 005	A	B	C	D	F	W	C or Higher
A	**-32%**	**33%**	5%	0%	-6%	0%	**6%**
B	-9%	8%	-5%	8%	-5%	2%	**-5%**
C	-1%	-2%	1%	**10%**	-8%	0%	-2%
D							
F							
W							
Total	-4%	**7%**	4%	**5%**	**-11%**	0%	**7%**

	Math 021						
Math 005	A	B	C	D	F	W	C or Higher
A	-5%	5%	**-25%**	**13%**	**13%**	0%	**-25%**
B	4%	**-22%**	13%	9%	-6%	3%	**-5%**
C	0%	-2%	**-18%**	0%	**11%**	9%	**-20%**
D							
F							
W							
Total	3%	**-6%**	-3%	2%	-1%	**6%**	**-6%**

Tradition Preparatory Calculus Course, Math 005

	Math 011						
Math 005	A	B	C	D	F	W	C or Higher
A	38%	38%	19%	0%	6%	0%	94%
B	12%	23%	54%	4%	8%	0%	88%
C	1%	16%	46%	12%	23%	2%	63%
D	0%	13%	42%	17%	17%	13%	54%
F	0%	21%	24%	21%	34%	0%	45%
W							
Total	6%	19%	42%	11%	19%	2%	67%

	Math 021						
Math 005	A	B	C	D	F	W	C or Higher
A	30%	20%	50%	0%	0%	0%	100%
B	1%	27%	36%	13%	20%	3%	64%
C	0%	12%	41%	15%	32%	1%	53%
D	0%	0%	22%	28%	50%	0%	22%
F	0%	0%	18%	45%	36%	0%	18%
W							
Total	2%	16%	37%	16%	28%	1%	54%

Hybrid Preparatory Calculus Course, Math 005

	Math 011						
Math 005	A	B	C	D	F	W	C or Higher
A	6%	71%	24%	0%	0%	0%	100%
B	3%	31%	49%	12%	3%	2%	83%
C	0%	14%	48%	22%	15%	2%	61%
D							
F							
W							
Total	2%	26%	46%	16%	9%	2%	74%

	Math 021						
Math 005	A	B	C	D	F	W	C or Higher
A	25%	25%	25%	13%	13%	0%	75%
B	5%	5%	49%	22%	14%	5%	59%
C	0%	10%	23%	15%	43%	10%	33%
D							
F							
W							
Total	5%	9%	34%	18%	27%	7%	48%

Why are there grades in calculus for students with a grade below C in Preparatory Calculus? While a grade of C or higher is a prerequisite for the subsequent calculus course, performance can be demonstrated by transfer coursework and some students in a traditionally taught Math 005 repeated Math 005 as a hybrid course.
Math 005 clusters had to be of 10 or more students before percentages were displayed. Differences of 10% or more in table or 5% or more at margins are highlighted.

Table 4: Math Ability and Performance in Calculus by Traditional or Hybrid Precalculus Course Using Grade Points and Letter Grades

Middle 50% (SAT Math 470-580)

Hybrid Advantage (Hybrid - Traditionally Taught)

	Math 011						
Math 005	A	B	C	D	F	W	C or Higher
A	**-17%**	**15%**	9%	-1%	0%	-6%	**7%**
B	0%	2%	-1%	1%	-1%	0%	1%
C	3%	-3%	0%	7%	-5%	-2%	0%
D	**-10%**	**-20%**	**-33%**	**-10%**	**-27%**	0%	**-63%**
F							
W							
Total	0%	**7%**	0%	0%	**-6%**	-2%	**8%**

	Math 021						
Math 005	A	B	C	D	F	W	C or Higher
A	**-14%**	4%	5%	1%	1%	2%	-4%
B	-3%	**-14%**	9%	8%	1%	-2%	**-8%**
C	1%	-7%	-2%	7%	0%	1%	**-8%**
D							
F							
W							
Total	-2%	-3%	**5%**	4%	-4%	0%	0%

Tradition Preparatory Calculus Course, Math 005

	Math 011						
Math 005	A	B	C	D	F	W	C or Higher
A	43%	33%	16%	2%	0%	6%	92%
B	7%	32%	44%	9%	8%	1%	82%
C	1%	11%	47%	15%	21%	4%	60%
D	10%	20%	33%	10%	27%	0%	63%
F							0%
W							
Total	10%	22%	40%	11%	14%	3%	72%

	Math 021						
Math 005	A	B	C	D	F	W	C or Higher
A	27%	42%	26%	2%	2%	1%	95%
B	7%	33%	35%	8%	13%	4%	75%
C	0%	13%	35%	15%	33%	4%	48%
D	7%	0%	29%	21%	43%	0%	36%
F	0%	20%	20%	0%	60%	0%	40%
W							
Total	8%	26%	33%	10%	20%	3%	67%

Hybrid Preparatory Calculus Course, Math 005

	Math 011						
Math 005	A	B	C	D	F	W	C or Higher
A	25%	48%	25%	1%	0%	0%	99%
B	7%	33%	43%	10%	7%	0%	83%
C	4%	8%	48%	22%	16%	2%	60%
D							
F							
W							
Total	10%	29%	40%	11%	9%	1%	79%

	Math 021						
Math 005	A	B	C	D	F	W	C or Higher
A	13%	46%	31%	3%	3%	3%	91%
B	4%	18%	45%	16%	15%	2%	67%
C	2%	6%	33%	22%	33%	5%	41%
D							
F							
W							
Total	6%	22%	38%	14%	16%	3%	67%

Why are there grades in calculus for students with a grade below C in precalculus? While a grade of C or higher is a prerequisite for the subsequent calculus course, performance can be demonstrated by transfer coursework and some students in a traditionally taught Math 005 repeated Math 005 as a hybrid course.

Math 005 clusters had to be of 10 or more students before percentages were displayed. Differences of 10% or more in table or 5% or more at margins are highlighted.

Top Quarter (SAT Math 590-800)

Hybrid Advantage (Hybrid - Traditionally Taught)

	Math 011						
Math 005	A	B	C	D	F	W	C or Higher
A	**-17%**	**11%**	6%	0%	0%	0%	0%
B	-5%	4%	1%	3%	-3%	0%	0%
C	0%	**-13%**	38%	**-19%**	**-13%**	7%	**25%**
D							
F							
W							
Total	-4%	3%	**8%**	-4%	-4%	1%	**7%**

Tradition Preparatory Calculus Course, Math 005

	Math 011						
Math 005	A	B	C	D	F	W	C or Higher
A	59%	27%	14%	0%	0%	0%	100%
B	19%	32%	32%	8%	8%	0%	84%
C	0%	20%	27%	33%	20%	0%	47%
D							
F							
W							
Total	26%	28%	26%	12%	9%	0%	79%

Hybrid Preparatory Calculus Course, Math 005

	Math 011						
Math 005	A	B	C	D	F	W	C or Higher
A	42%	39%	19%	0%	0%	0%	100%
B	14%	36%	33%	11%	6%	0%	83%
C	0%	7%	64%	14%	7%	7%	71%
D							
F							
W							
Total	22%	31%	34%	7%	5%	1%	87%

Table 4: Math Ability and Performance in Calculus by Traditional or Hybrid Precalculus Course Using Grade Points and Letter Grades

	Math 021						
Math 005	A	B	C	D	F	W	C or Higher
A	**-18%**	7%	-2%	13%	0%	0%	**-13%**
B	4%	-5%	**14%**	-3%	-9%	-2%	**14%**
C	-1%	-2%	**31%**	7%	**-30%**	-5%	**27%**
D							
F							
W							
Total	-3%	0%	**13%**	3%	**-10%**	-2%	**9%**

	Math 021						
Math 005	A	B	C	D	F	W	C or Higher
A	38%	35%	23%	0%	4%	0%	96%
B	4%	42%	29%	8%	15%	2%	75%
C	8%	21%	26%	5%	36%	5%	54%
D							
F							
W							
Total	15%	35%	27%	5%	16%	2%	77%

	Math 021						
Math 005	A	B	C	D	F	W	C or Higher
A	21%	42%	21%	13%	4%	0%	83%
B	9%	37%	43%	4%	7%	0%	89%
C	6%	19%	56%	13%	6%	0%	81%
D							
F							
W							
Total	12%	35%	40%	8%	6%	0%	86%

Why are there grades in calculus for students with a grade below C in precalculus? While a grade of C or higher is a prerequisite for the subsequent calculus course, performance can be demonstrated by transfer coursework and some students in a traditionally taught Math 005 repeated Math 005 as a hybrid course.
Math 005 clusters had to be of 10 or more students before percentages were displayed. Differences of 10% or more in table or 5% or more at margins are highlighted.

Table 5: Likelihood of Repeating Preparatory Calculus by Instructional Method

	A	B	C	D	F	W	Overall
Traditional Math 005							
Repeated	3%	13%	20%	64%	50%	41%	**25%**
Took One Time	97%	87%	80%	36%	50%	59%	75%
Hybrid Math 005							
Repeated	1%	5%	10%	47%	30%	28%	**12%**
Took One Time	99%	95%	90%	53%	70%	72%	88%

Why would students with an A repeat? The letter grade displayed is the last grade earned in the class.