Outcomes Within the Two CCP Calculus Sequences and Subsequent Enrollment and Performance in Higher Level Mathematics and Engineering Courses

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In Fall 1988 the Mathematics Department began offering a differential calculus sequence (Math 165/166) in addition to the traditional precalculus/calculus sequence (Math 161/162/171). Upon completion of either sequence, a student became eligible for enrollment in Math 172 or Engineering 172[1]. Upon completion of Math/Engineering 172 students could continue their studies with upper-level mathematics courses offered through the Engineering Department.

The two sequences offer different approaches to teaching the same underlying subject matter. The newer sequence attempts to accomplish the preparation of students for upper-level courses in two semesters rather than the three semesters the traditional sequence takes, and attempts to do so by placing the emphasis on "understanding and Calculus literacy rather than computational mastery" (Community College of Philadelphia 90/92 Catalog, p. 125).

In order to evaluate the relative merits of the two sequences, a number of questions need to be addressed:

1. What percentage of students starting a sequence ultimately finish it?
2. How long does it take the average student to complete a sequence?

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[1] Courses in the Engineering 161/162/171 sequence are considered equivalent to their like-numbered courses in the traditional Mathematics sequence. Therefore, for purposes of this study, when a student is classified as having enrolled in a traditional precalculus/calculus sequence, they may have taken courses through either the Mathematics or Engineering departments, or both. Likewise, Engineering 172 is considered equivalent to Mathematics 172.

3. How well does each sequence prepare students for the upper-level courses?

4. Are the outcomes in the two sequences different by race or gender of student?

In order to answer these questions, a database composed of all students enrolled at any time between Fall 1988 and Summer II 1991 in at least one of the five Math Department courses in the traditional or differential calculus sequences was compiled. In addition to information about grades received in these courses, the database contained information about the number of times each course was attempted, the semester of enrollment for the final attempt of each course, grades in upper-level math and engineering courses, and gender and race information.

Information was available for 2923 students. Of these, 797 (27.3%) never passed a course in either calculus sequence, 1726 (59%) passed at least one course in the traditional sequence, 335 (11.5%) passed at least one of the two courses in the differential sequence, and 65 (2.2%) passed at least one course in both sequences.

Of the 1726 in the traditional sequence, 1355 passed Math 161 with a grade of C or better. Ten other students attempted Math 161 without such success, but were able to pass at least one other course in the sequence. The remaining 361 students identified in this sequence skipped Math 161 and entered Math 162 or Math 171 directly. Only one student in the differential calculus sequence was able to pass Math 166 despite attempting

and failing to pass Math 165. No other students entered directly into Math 166.

Limiting the sample to those who passed the first course in their respective sequences, 841 (62.1%) of the 1355 traditional calculus sequence students took no further classes in the sequence; 208 (62.3%) of the 334 differential calculus students did not enroll for the second course. Of the 514 students in the traditional sequence who continued their studies in the sequence, 458 (89.1%) passed either Math 162 or Engineering 162 and 219 (42.6%) passed either Math 171 or Engineering 171. Of those who entered and passed the first course in each sequence then, 126 (37.7%) of the 334 differential calculus students completed the sequence and 163 (12.0%) of the 1355 traditional sequence students completed all three courses in that sequence. An additional 56 (4.1%) of the traditional calculus sequence students passed either Math 171 or Engineering 171 without having first passed Math 162 or Engineering 162. (See Table 1.)

Of those attempting the first course in their respective calculus sequence, 654 did so between Fall 1988 and Fall 1989[2]. While 67 (12.5%) of the 538 traditional track students finished that sequence, 56 (48.3%) of the 116 differential calculus sequence students did likewise, revealing an association between the latter sequence and completion ($\chi^2(1) = 82.14$, $p < .001$). However, it is important to note that the group of students who completed the highest course in the traditional sequence (Math

[2] Fall 1988 was chosen as one endpoint because that was the first semester in which the differential calculus sequence was offered; Fall 1989 was chosen as the other endpoint because it allowed students two complete calendar years to complete their chosen sequence.

171 or Engineering 171) without first passing Math 162 or Engineering 162 are counted among the non-completers here. If the additional requirement of passing Math 172 or Engineering 172 is added, 27 (5.0%) of the 538 traditional sequence students completed all courses, while 6 (5.2%) of the 116 differential calculus students did likewise. (See Table 2.)

The 67 students who completed all three courses in the traditional calculus sequence took an average of 3.99 semesters (including Summer sessions) beyond Math 161 to complete their sequence. The 56 differential calculus completers took an average 1.93 semesters (including Summer sessions) beyond Math 165 to complete Math 166 ($F(1, 121) = 41.88$, $p < .001$). Since two additional courses are required in order to complete the traditional sequence instead of the one additional course required to complete the differential sequence, this finding is not unexpected.

Considering again all students who passed at least one of the courses in either the traditional or differential calculus sequences, 227 from the traditional sequence attempted Math 172 or Engineering 172, while 30 from the differential calculus track did likewise. Of the 227 in the traditional calculus sequence, 178 (78.4%) passed Math/Engineering 172 with a grade of C or better. Of the 93 who completed this sequence (took all three courses), 75 (80.6%) passed. Nineteen (63.3%) of the 30 who took one of the differential calculus courses passed Math/Engineering 172; 18 (64.3%) of the 28 completers of this sequence passed. (See Table 3.)

Of the 34 students who attempted Engineering 270, only one passed through the differential calculus sequence. This lone student did not successfully complete the course, while 29 of 33 (87.9%) exposed to the traditional sequence did successfully complete the course. All 14 of those who took all three courses in the traditional sequence passed Engineering 270.

Both differential calculus students who attempted Engineering 271 passed, while 26 of 37 (70.3%) of the traditional track students did likewise. No student from the differential calculus sequence attempted Engineering 272. Twenty of 27 (74.1%) exposed to one course in the traditional sequence and 13 of 14 (92.9%) completers of the sequence passed this course.

White students were slightly overrepresented in the differential calculus sequence while Asians were overrepresented in the traditional sequence. Blacks were less likely to complete either sequence than the overall student population, while white and Asian students were more likely to complete either sequence. Hispanic students were less likely to complete the traditional sequence but more likely to complete the differential calculus sequence. (See Table 4.)

The higher success in Mathematics and Engineering 172 associated with enrollment in the traditional calculus sequence was consistent across all racial groups. However, males enrolled in the differential calculus sequence did slightly better in terms of Math/Engineering 172 performance than did their colleagues who advanced through the traditional sequence. Females enjoyed no such benefit. (See Table 5.)

Table 1

Progression of Students Passing the First Course in a Calculus Sequence Through Subsequent Courses

Sequence	Number	Percent
Traditional	1355	
Passed 161 only	841	62.1%
Passed 161 & 162 only	295	21.8%
Passed 161 & 171 only	56	4.1%
Passed 161, 162 & 171	163	12.0%
Differential Calculus	334	
Passed 165 only	208	62.3%
Passed 165 & 166	126	37.7%

Note. An earned grade of C or better is considered passing.

Table 2

Progression of Students Attempting the First Course in a Calculus Sequence between Fall 1988 and Fall 1989

Thorugh Subsequent Courses and Math/Engineering 172

Sequence	Number	Number passing M/E 172	Percent passing M/E 172
Traditional			
Passed 161 only	326	1	0.3%
Passed 162 only	3	0	0.0%
Passed 171 only	1	0	0.0%
Passed 161 & 162 only	111	0	0.0%
Passed 161 & 171 only	30	13	43.3%
Passed 161, 162 & 171	67	27	40.3%
TOTAL	538	41	7.6%
Differential Calculus			
Passed 165 only	59	1	1.7%
Passed 166 only	1	0	0.0%
Passed 165 & 166	56	6	10.7%
TOTAL	116	7	6.0%

Note. An earned grade of C or better is considered passing.

Table 3

Outcomes of Students in Advanced Mathematics and Engineering Courses

Sequence		Course			
		Math172/ Engr 172	Engr 270	Engr 271	Engr 272
Traditional					
Passed at least one course	(N = 1726)				
Number attempting		227	33	37	27
Percent attempting		13.2%	1.9%	2.1%	1.6%
Number passing (A, B, C)		178	29	26	20
Percent of attempters passing		78.4%	87.9%	70.3%	74.1%
Completed sequence	(N = 163)				
Number attempting		93	14	21	14
Percent attempting		57.1%	8.6%	12.9%	8.6%
Number passing (A, B, C)		75	14	14	13
Percent of attempters passing		80.6%	100.0%	66.7%	92.9%
Differential Calculus					
Passed at least one course	(N = 335)				
Number attempting		30	1	2	0
Percent attempting		9.0%	0.3%	0.6%	0.0%
Number passing (A, B, C)		19	0	2	NA
Percent of attempters passing		63.3%	0.0%	100.0%	NA
Completed sequence	(N = 126)				
Number attempting		28	0	1	0
Percent attempting		22.2%	0.0%	0.8%	0.0%
Number passing (A, B, C)		18	NA	1	NA
Percent of attempters passing		64.3%	NA	100.0%	NA

Table 4

Completion Status of Students Passing the First Course in a Calculus Sequence

by Racial/Ethnic Group and by Gender

	Sequence					
	Traditional			Differential Calculus		
Group	Number passing Math 161	Number completing sequence	Percent of attempters completing	Number passing Math 165	Number completing sequence	Percent of attempters completing
Race/Ethnicity						
Black	423	39	9.2%	101	32	31.7%
White	549	69	12.6%	156	61	39.1%
Asian	251	42	16.7%	37	16	43.2%
Hispanic	58	3	5.2%	14	9	64.3%
Other/Unknown	74	10	13.5%	26	8	30.8%
Gender						
Female	650	66	10.2%	162	63	38.9%
Male	703	97	13.8%	172	63	36.6%

Table 5

Success in Math 172/Engineering 172 by Racial/Ethnic Group and by Gender

Group	Sequence											
	Traditional						Differential Calculus					
	Passed at least one course			Completed sequence			Passed at least one course			Completed sequence		
	Number attempting M/E 172	Number passing M/E 172	Percent of attempters passing	Number attempting M/E 172	Number passing M/E 172	Percent of attempters passing	Number attempting M/E 172	Number passing M/E 172	Percent of attempters passing	Number attempting M/E 172	Number passing M/E 172	Percent of attempters passing
Race/Ethnicity												
Black	53	33	62.3%	24	15	62.5%	6	1	16.7%	5	1	20.0%
White	77	60	77.9%	36	31	86.1%	16	12	75.0%	16	12	75.0%
Asian	77	68	88.3%	26	23	88.5%	7	5	71.4%	6	4	66.7%
Hispanic	6	3	50.0%	1	0	0.0%	0	NA	NA	0	NA	NA
Other/Unknown	14	14	100.0%	6	6	100.0%	1	1	100.0%	1	1	100.0%
Gender												
Female	140	110	78.6%	27	23	85.2%	13	4	30.8%	12	4	33.3%
Male	87	68	78.2%	66	52	78.8%	17	15	88.2%	16	14	87.5%