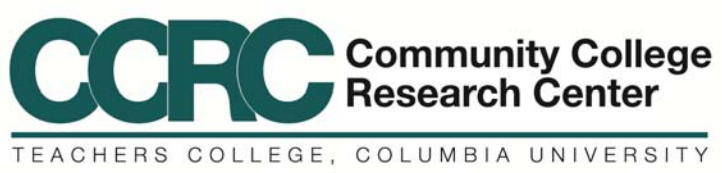

Not Just Math and English:
Courses That Pose Obstacles to Community College Completion

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Abstract

Discussions of the barriers to completion in community colleges have largely focused on student success in introductory college-level math and English courses, and rightfully so, since these courses are typically required for degrees. However, there is a much broader range of courses that also serve as "gatekeepers" in the sense that they are obstacles to completion. This paper offers methods for identifying these courses and for assessing the relative extent of the obstacle to completion each of them poses. We compare the performance in these courses of students who successfully completed a credential with those who did not.

We find that the difficulty students experience in succeeding in many other introductory courses is just as great as that posed by college math and English. If colleges want to reduce impediments to graduation, they therefore need to look at a broader range of courses than just math and English and devise strategies for improving student achievement in these courses as well.

We also find that overall GPA in college courses is a stronger predictor of completion than performance in any one course. This suggests that colleges need to monitor students' overall performance to identify those who are in danger of not completing and design academic and non-academic interventions to help them succeed. Conversely, colleges need also to identify students who did well in these obstacle courses but have dropped out, so that they can encourage them to continue. It also suggests that remedial instruction, which is typically focused on math and English, should be rethought and its scope broadened.

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1. Introduction

In discussions of the academic barriers to student completion in community colleges, much of the focus has been on developmental education and introductory, or "gatekeeper," college-level math and English courses. This focus is warranted. Introductory math and English courses are generally required for most degrees, yet many students never complete them. And this is particularly true of those incoming students who are referred to remedial or "developmental" courses (Bailey, Jeong, & Cho, 2010; Jenkins, Jaggars, Roksa, Zeidenberg, & Cho, 2009), courses which are aimed at preparing students to take and pass college-level math and English. Both developmental education and gatekeeper courses in math and English indeed function as obstacles to completion for many students. However, because completing college requires much more than simply completing developmental instruction and passing college-level math and English, a focus on these courses is necessary but not sufficient. There are a wide variety of courses that a student must successfully complete in order to earn a credential. Some of these are introductory courses in particular fields such as business, nursing, or science. As with the entry-level math and English, such introductory courses tend to enroll large numbers of students. Failure rates in many of these courses are high, suggesting that they too may serve as significant obstacles to completion.

This paper offers methods to identify and assess commonly taken courses that serve as obstacles to completion for community college students. These methods may be relevant for colleges that want to allocate resources toward addressing those courses that are the most obstructive to student completion. Colleges can use information on student performance in such courses to identify and provide assistance to those students who are struggling before students drop out. Based on this paper's findings, it appears likely that by improving student performance in these courses, colleges may be able to improve their graduation rates, as such courses are important milestones along the pathways to completion.

Prior research on course-level barriers to completion has largely focused on gatekeeper math and English. Goldrick-Rab (2010) recently reviewed the research literature on the relationship between student success and the factors that influence it. In

examining individual courses that influence success, she discussed research showing that, in both Florida and Virginia, students who succeed in gatekeeper math and English have a higher chance of completing a credential (Bailey, Calcagno, Jenkins, Leinbach, & Kienzl, 2006; Jenkins et al., 2009). In the review, Goldrick-Rab cited research only on developmental courses and gatekeeper math and English courses, presumably because rigorous research on the effects of other courses was uncommon or nonexistent. In McClenney and Marti's (2006) study of the relationship between measures of student engagement and community college outcomes, developmental and gatekeeper math and English course outcomes were the only individual course outcomes that were included.

The focus on entry-level math and English is also seen in measures employed in college accountability and performance improvement models. In their review of accountability systems used by states, Dougherty, Hare, and Natow (2009) noted that completion of developmental courses and enrollment gatekeeper math and English courses were often used as benchmarks, while more general measures of student learning were relatively rarely used. We also note that the large and prominent Achieving the Dream initiative[1] encourages colleges to use student performance in gatekeeper math and English as one of the primary metrics of improvement and of student progress along a pathway.

The closest parallel we have found to the approach used in this paper is the work of Hagedorn, Cypers, and Lester (2008), which examined students who transferred from community colleges to four-year institutions. The authors found that the most predictive factor for transfer was enrolling in and passing courses in the transfer curriculum. In the present paper, while we focus on the completion of community college credentials rather than on transfer, we consider all common courses that may serve as barriers, not merely developmental and entry-level math and English. Our work is also closely related to the work of Jenkins and Cho (2012), who argued that success in various program-specific introductory courses (in addition to completing college-level math and English) is necessary for success in a college program and therefore in obtaining a credential.

[1] Conceived as a foundation-sponsored initiative in 2004, Achieving the Dream is a national nonprofit organization dedicated to helping more community college students succeed, particularly low-income students and students of color. Achieving the Dream focuses on measuring rates of student progression in order to engage in a continuous improvement process at community colleges. See www.achievingthedream.org

The focus on gatekeeper math and English as milestones along a path to completion has also led to a focus on factors that influence student success in these courses. Cox (2009) wrote about how faculty and colleges can promote student success in a gatekeeper college composition course by explicitly addressing students' fear of failure. Hoffman, Vargas, and Santos (2009) suggested that ultimate student success rates could possibly be increased by requiring students to enroll in college-level gatekeeper math and English while still in high school. Gainen (1995) argued that student performance in introductory quantitative college-level courses could be boosted by attending to four factors related to performance: precollege preparation, peer culture, classroom culture, and instructional style. And Perin (2011) suggested that student performance in gatekeeper math and English could be improved by contextualization. This method teaches math and English in the context of other subjects, such as nursing or business, which are of interest to students. The extent to which some of these suggestions and other similar ideas would also apply to other courses in which students struggle, in addition to gatekeeper math and English, is a question worth pursuing. It is reasonable to think they would be relevant.

This paper examines *all* commonly taken courses that serve as obstacles to completion for community college students. Colleges sometimes identify "obstacle" courses as those with both high enrollments and high failure rates. In this paper, we identify obstacle courses by comparing student performance in courses frequently taken by students who completed associate degree programs with that of credential-seeking students who did not complete a degree program. Obstacle courses are those that non-completers did substantially worse in (either based on differences in grades or failure rates) than students who completed a program. This paper contributes to ongoing research by using differences in grades between completers and non-completers among frequently taken courses as a way to identify courses that serve as barriers to completion. Once we identify these critical obstacle courses, we then investigate the relationships between performance in individual courses and program completion.

This paper is organized as follows. First, we compare the course performance of completers and non-completers in order to identify obstacle courses overall and in several popular degree programs among community college students in a given state. Next, we

conduct a series of analyses of grades in obstacle courses to see how much better completers do in them than do non-completers. We then compare the relationships between completing a community college credential and grades in pairs of courses, where one of the courses is gatekeeper math or English and the other is another obstacle course. The purpose is to assess the extent to which courses outside of math and English serve as obstacles to college completion relative to college math and English. Then we use propensity score models to analyze the relationship between first-semester performance in individual obstacle courses and completion of a community college credential. Finally, we examine the relationship between student GPA and completion.

Our findings indicate that despite the focus on college math and English, these courses are not the only obstacles to completion for community college students. In fact, they present no greater obstacle to completion than the other gatekeeper courses that are identified in this paper. Other introductory college-level courses also serve as obstacles to earning a college credential. Not surprisingly, these vary somewhat by program.

Thus, if colleges want to increase students' chances of earning a credential, they will need to pay attention to student performance in a broader set of courses beyond simply college math and English. They should also rethink college remediation or developmental instruction, which tends to focus on math and English and not on other obstacle courses.

Completers do much better than non-completers in obstacle courses (including introductory math, English, and other introductory courses), in terms of both higher grades and lower failure rates. We also find that overall GPA is an even better predictor of completion than grades in individual courses, so colleges should monitor aggregate GPA as well as performance in key courses in order to identify students who are struggling. Of course, grades are largely measures of student characteristics such as motivation, prior learning, other commitments, and so forth. While we find that completers generally have higher grades than non-completers, there are substantial numbers of non-completers who have good grades and yet do not complete. This suggests that colleges could improve their outreach to such students and encourage them to stay in or return to school and complete a credential. Colleges can also work on improving their academic and non-academic services, such as tutoring and counseling.

2. Data

For our analysis, we considered six combined cohorts of credential-seeking community college students from a single state system. These cohorts of students entered colleges in the system for the first time between 2004 and 2009. We had their complete transcripts from any college within the system, including their grades. We also had a list of awards for each student who earned any award. Of the 160,212 students in these cohorts, 17,653, or about 11 percent, completed an award from a community college in this system over the period from fall 2004 to fall 2009; the remaining 142,559 did not. The data also included information on student demographics.

3. Identifying Obstacle Courses by Comparing Completers and Non-Completers

We first examined the gaps in grades between students who completed a credential in the period given above and those who did not complete in order to assess which courses function as obstacle courses in various programs. Table 1 shows the top 25 college-level (non-developmental) courses, sorted in descending order of frequency of enrollment by completing students. The introductory college-level math and English and math courses are College Composition I and II (ranked 1 and 3 in this list) and Precalculus I and Mathematics for the Liberal Arts (ranked 9 and 20).

This list of courses is dominated by liberal arts[2] subjects such as history, biology, psychology, and economics, because most of the students in this state system are on a liberal arts, transfer track. These frequently taken courses can be thought of as additional obstacle courses or *gatekeepers*. We feel that these two terms should be used interchangeably, but in deference to current usage, we use the term *obstacle courses* to refer to the broader list of courses beyond English and math. The degree to which a course is an obstacle can be measured by its failure rate.

[2] Here we use the term *liberal arts* to include arts, humanities, social and behavioral science, and physical and biological sciences, and we exclude career-oriented fields such as nursing and allied health, business, and information technology.

Table 1

Top 25 Courses by Enrollment Taken by Completing Students, and Comparisons of Enrollment Rate and Grades with Non-Completing Students

		Enrollment Rate				Mean Grade			Failure Rate		
Rank	Course Title	Overall	Completers	Non-Completers	Difference	Completers	Non-Completers	Difference	Completers	Non-Completers	Difference
1	College Composition I	59.5%	75.4%	57.5%	17.9%	3.2	2.5	0.7	0.8%	14.0%	13.2%
2	College Success Skills	42.3%	47.4%	41.6%	5.8%	3.5	2.8	0.7	0.6%	12.1%	11.5%
3	College Composition II	36.7%	68.6%	32.7%	35.9%	3.2	2.6	0.6	0.9%	10.7%	9.8%
4	Introduction to Computer Applications and Concepts	34.4%	57.5%	31.5%	25.9%	3.4	2.5	0.9	0.8%	16.5%	15.6%
5	United States History I	26.4%	44.1%	24.2%	20.0%	3.1	2.3	0.8	1.3%	15.7%	14.4%
6	General Biology I	22.5%	43.2%	20.0%	23.3%	2.9	2.1	0.7	1.5%	16.3%	14.8%
7	United States History II	16.9%	36.3%	14.5%	21.8%	3.2	2.5	0.7	1.0%	12.3%	11.3%
8	Introduction to Psychology I	16.4%	24.3%	15.4%	8.9%	3.2	2.4	0.8	1.7%	15.3%	13.6%
9	Precalculus I	13.6%	31.9%	11.4%	20.5%	2.8	2.2	0.6	2.6%	17.4%	14.8%
10	History of Western Civilization I	13.1%	20.0%	12.3%	7.7%	3.1	2.3	0.8	1.9%	18.1%	16.2%
11	General Biology II	12.4%	37.5%	9.3%	28.2%	2.9	2.4	0.5	1.0%	9.0%	8.0%
12	Introduction to Business	12.3%	17.8%	11.6%	6.2%	3.1	2.3	0.8	1.4%	17.8%	16.4%
13	Principles of Psychology	11.3%	20.8%	10.1%	10.6%	3.0	2.3	0.7	1.6%	16.8%	15.2%
14	Principles of Public Speaking	11.3%	32.1%	8.7%	23.4%	3.4	2.6	0.8	0.6%	13.5%	12.9%
15	Principles of Sociology	10.7%	20.8%	9.4%	11.3%	3.1	2.4	0.7	1.7%	14.2%	12.5%
16	Principles of Macroeconomics	10.5%	25.8%	8.7%	17.1%	2.9	2.3	0.7	1.9%	16.0%	14.2%
17	Introduction to Speech Communication	9.7%	25.0%	7.8%	17.2%	3.4	2.7	0.7	0.7%	12.0%	11.3%
18	Principles of Accounting I	8.9%	19.6%	7.5%	12.1%	2.9	2.1	0.8	3.0%	22.5%	19.5%
19	Lifetime Fitness and Wellness	8.8%	16.2%	7.9%	8.4%	3.4	2.7	0.7	0.9%	12.7%	11.7%
20	Mathematics for the Liberal Arts I	8.5%	18.3%	7.3%	10.9%	2.9	2.3	0.6	1.3%	15.1%	13.8%
21	Orientation to (specify the discipline)	8.1%	9.8%	7.9%	1.9%	3.6	3.1	0.5	1.9%	10.7%	8.8%
22	Introduction to Sociology I	7.9%	13.4%	7.2%	6.2%	3.2	2.6	0.6	1.5%	12.5%	11.0%
23	Developmental Psychology	7.7%	14.4%	6.9%	7.5%	3.2	2.6	0.7	1.3%	13.4%	12.2%
24	Principles of Microeconomics	6.6%	19.5%	5.0%	14.5%	3.1	2.5	0.6	1.6%	12.5%	10.9%
25	Beginning Spanish I	6.1%	12.8%	5.3%	7.5%	3.2	2.4	0.8	2.8%	17.7%	14.8%
	Overall Mean					3.2	2.5	0.7	1.4%	14.6%	13.1%

Note. Differences are in terms of percentage points in the cases of the enrollment rates and failure rates.

As will become clear, completers had very low failure rates in these obstacle courses; non-completers had substantially higher failure rates. Thus, since there is a high risk of failure in many of these courses, they constitute obstacles to successful completion.

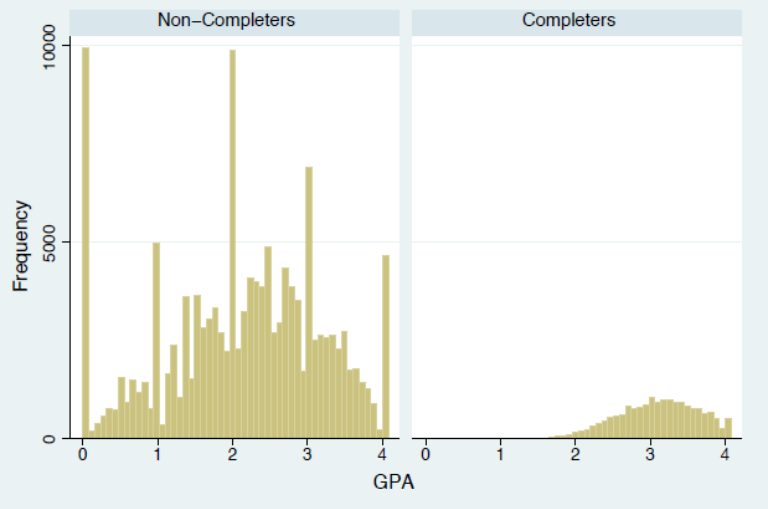
The second most frequently taken course was a college success course. In the state from which these data were drawn, students are generally required to take such a course, although this requirement has become enforced more strictly in recent years. Another discipline-specific version of such a course is on the list at position 21.

We can draw three main conclusions from Table 1. First, for every course on the list, completers enrolled at a higher rate. This is not surprising, because completers enrolled in *more* courses overall; non-completers typically dropped out, often quite early in their college careers. The differences are notable and large not only for the English and math courses, but for several other courses as well, such as the introductory history, biology, public speaking, and computer courses. The enrollment rate for all students (completers and non-completers combined) was closer to that of the non-completers than the completers because the non-completers were much more numerous.

Second, the completers earned higher grades than the non-completers in every case in this list. The average grade for the non-completers across all of these courses was 2.5, or midway between a C and a B. The average grade for the completers was 3.2, slightly above a B. It may be that non-completers were discouraged from continuing due to their relatively low grades in these courses.

Completers had a higher median GPA, 3.1, than did non-completers, 2.2. The grade distribution of the completers is therefore higher. The 25th percentile GPAs of completers and non-completers, respectively, were 1.4 and 2.7. The 75th percentile GPAs were 2.9 and 3.5. (Thus there were some non-completers who received relatively higher grades; some of these students may have transferred and thus never received a lower division credential.) This is shown more vividly in the histograms of the GPAs of the non-completers and the completers in Figure 1. While non-completers had GPAs across the entire range from A to F, completers' GPAs were primarily found between A and C. This suggests that those non-completers with higher grades might have been able to complete a credential if they had simply remained enrolled in school.

Figure 1
GPAs of Non-Completers and Completers



Third, consonant with their lower grades, non-completers had a much higher failure rate in each of these courses.[3] The completers had a failure rate that was always below 3 percent and often below 1 percent. The non-completers had failure rates that ranged from 9 percent to 22.5 percent, with most of them falling in the teens. Notably, gatekeeper English (College Composition I, 14.0 percent) and gatekeeper math (Precalculus I, 17.4 percent) did not have the highest failure rates for non-completers among the group—History of Western Civilization I (18.1 percent), Introduction to Business (17.8 percent), Principles of Accounting I (22.5 percent), and Beginning Spanish I (17.7 percent) had higher failure rates.

One notable finding is that when a course was the second of a sequence, it had a lower failure rate, at least for the three examples on this list (College Composition, United States History, and General Biology.) Presumably this is because most of the students who failed the first course in the sequence never enrolled in the second, which led to a better prepared and more motivated pool of students.

[3] The failure rate is defined as the share of students receiving a grade of F or U, out of those receiving grades of A, B, C, D, F, or U. (Students can also receive a W [*withdrawal*] or an I [*incomplete*], which are not included in this calculation.)

Table 1 is descriptive and therefore cannot take into account unobservable characteristics that could account for some, although not all, of the differences between completers and non-completers. While we employ models to control for such differences later in the paper, this descriptive information is nevertheless important, irrespective of what the models reveal; whatever the attributes of students who are associated with success or failure might be, the unadjusted mean grades and failure rates represent the situation as educators can observe it, thus indicating what needs to be improved.

In what follows, we examine the obstacle courses for some of the most popular degree programs in the community college system from which our data were drawn. Students in this system typically pursue a transfer program, usually in liberal arts, so the first four degrees we considered are transfer programs (two in liberal arts, one in business). We then considered two non-transfer programs, one in nursing and one in information technology.[4] Of the non-transfer programs, these were among the most heavily enrolled. Again, here we are only looking at grade gaps and differences in failure rates descriptively; we are therefore are not controlling for all observable differences between completers and non-completers.

The results for the five programs examined are summarized in Table 2. We found a similar pattern to that found for individual courses with high rates of enrollment. For these five programs, the grade gap in the 25 most frequently enrolled courses, overall between completers of each program and all non-completers, ranged between 0.6 and 0.9. The largest gap, 0.9, was found for the Associate of Science (AS) in Science degree. The failure rate of non-completers in those courses ranged from 8.6 to 16.8 percent, with the low of 8.6 percent being for the Associate of Applied Science (AAS) in Nursing, and the high of 16.8 percent being for the AAS in Information Systems Technology. For the remaining three credentials, the failure rate for non-completers was about 14 percent. For completing students, the failure rates were very low, between 0.3 percent and 1.4 percent.

[4] While the Associate of Applied Science in Nursing program we examined here was not historically designed for transfer, some students were pursuing program variants that do allow transfer.

Table 2
Average Grades Across Top 25 Courses Taken by Completing and Non-Completing Students, All Students, and in Selected Fields

	Mean Grade			Failure Rate		
	Completers	Non-Completers	Difference	Completers	Non-Completers	Difference
All Students	3.2	2.5	0.7	1.4%	14.6%	13.1%
AA&S in General Studies	3.1	2.4	0.7	1.0%	14.0%	13.0%
AS in Science	3.3	2.5	0.9	0.7%	14.0%	13.3%
AS in Business Administration	3.1	2.4	0.7	0.7%	14.1%	13.4%
AAS in Nursing	3.3	2.6	0.6	0.3%	8.6%	8.3%
AAS in Information Systems Technology	3.2	2.4	0.8	0.6%	16.8%	16.1%

Completers thus performed better than non-completers, in terms of both grades and failure rates. In most cases, as found when we examined the individual courses in the remaining case studies, these gaps were not restricted to introductory math and English, but expressed themselves in a wide variety of introductory courses. Since the introductory courses outside math and English have comparable failure rates to math and English, they can be considered as much obstacles or gatekeepers for students as are math and English themselves, although performance in any one of these is correlated with performance in the others and likely reflects underlying student characteristics.

Table 3 is similar to Table 1, but is restricted only to completers of the Associate of Arts and Sciences (AA&S) in General Studies, which is one of the several liberal arts transfer degrees offered by this community college system. The courses in the table are similar to those in Table 1, (although the order is somewhat different) because, as we noted above, liberal arts students have generally dominated this community college system.

It appears that some of the top-ranked courses in terms of the enrollment of completers were comparably large obstacles to completion, as were college-level math and English. As was the case with Table 1, completers did systematically better in these courses than non-completers. Many of these courses had high failure rates comparable to those of introductory math and English. The system offers a liberal arts transfer degree with a focus on science, which is the AS in Science. It appears, by looking at the top

enrollment courses shown in Table 4, that the main difference between these students and other liberal arts students was that they enrolled in more chemistry courses.

Table 3
Completers of the Associate of Arts and Sciences in General Studies, Enrollment Rate and Comparison of Grades with Non-Completers

		Enrollment Rate	Mean Grade			Failure Rate		
Rank	Course Title	Completers in this Field	Completers in this Field	All Non-Completers	Difference	Completers	Non-Completers	Difference
1	College Composition II	95.1%	3.1	2.6	0.5	0.4%	10.7%	10.3%
2	College Composition I	91.7%	3.2	2.5	0.7	0.2%	14.0%	13.8%
3	General Biology II	78.7%	2.9	2.4	0.5	0.5%	9.0%	8.5%
4	General Biology I	76.4%	2.9	2.1	0.8	0.5%	16.3%	15.8%
5	United States History I	73.5%	3.1	2.3	0.8	0.4%	15.7%	15.3%
6	United States History II	72.8%	3.2	2.5	0.7	0.6%	12.3%	11.7%
7	Introduction to Computer Applications and Concepts	71.6%	3.5	2.5	0.9	0.6%	16.5%	15.9%
8	Principles of Psychology	58.2%	3.1	2.3	0.8	1.1%	16.8%	15.7%
9	Precalculus I	55.6%	2.8	2.2	0.6	2.7%	17.4%	14.7%
10	College Success Skills	51.6%	3.5	2.8	0.6	0.4%	12.1%	11.7%
11	Principles of Public Speaking	49.6%	3.4	2.6	0.8	0.5%	13.5%	13.0%
12	Principles of Sociology	49.2%	3.2	2.4	0.8	0.5%	14.2%	13.7%
13	Survey of American Literature I	43.5%	3.0	2.5	0.5	1.3%	10.6%	9.3%
14	Mathematics for the Liberal Arts I	39.2%	2.8	2.3	0.5	0.7%	15.1%	14.4%
15	Survey of American Literature II	36.3%	3.1	2.6	0.5	1.1%	10.8%	9.7%
16	Mathematics for the Liberal Arts II	33.9%	2.7	2.3	0.4	0.9%	13.2%	12.3%
17	Introduction to Speech Communication	33.4%	3.5	2.7	0.7	0.4%	12.0%	11.6%
18	History of Western Civilization I	27.0%	3.1	2.3	0.9	1.4%	18.1%	16.7%
19	Precalculus II	26.7%	2.7	2.3	0.4	1.2%	13.3%	12.1%
20	Music Appreciation I	25.8%	3.3	2.5	0.7	1.2%	16.1%	14.9%
21	Principles of Macroeconomics	25.2%	3.1	2.3	0.8	2.0%	16.0%	14.0%
22	History of Western Civilization II	24.7%	3.2	2.4	0.8	0.8%	15.6%	14.8%
23	Developmental Psychology	24.7%	3.3	2.6	0.7	0.8%	13.4%	12.7%
24	U.S. Government I	21.1%	3.3	2.5	0.7	0.6%	10.9%	10.3%
25	History and Appreciation of Art I	19.3%	3.1	2.4	0.7	3.3%	16.8%	13.5%
	Overall Mean		3.1	2.4	0.7	1.0%	14.0%	13.0%

Table 4
Completers of the Associate of Science in Science,
Enrollment Rate and Comparison of Grades with Non-Completers

		Enrollment Rate	Mean Grade			Failure Rate		
Rank	Course Title	Completers in this Field	Completers in this Field	All Non-Completers	Difference	Completers	Non-Completers	Difference
1	College Composition II	90.5%	3.4	2.6	0.8	0.0%	10.7%	10.7%
2	College Composition I	82.9%	3.3	2.5	0.9	0.7%	14.0%	13.2%
3	General Biology II	72.1%	3.3	2.4	0.9	0.0%	9.0%	9.0%
4	General Biology I	71.3%	3.3	2.1	1.2	0.4%	16.3%	15.9%
5	College Chemistry I	68.8%	3.0	2.2	0.8	1.6%	16.6%	15.0%
6	College Chemistry II	66.2%	2.9	2.4	0.6	0.9%	9.9%	8.9%
7	College Success Skills	61.4%	3.5	2.8	0.7	1.0%	12.1%	11.1%
8	United States History I	58.4%	3.4	2.3	1.1	0.5%	15.7%	15.2%
9	Introduction to Psychology I	56.3%	3.5	2.4	1.1	0.3%	15.3%	15.0%
11	Principles of Public Speaking	52.1%	3.5	2.6	0.8	0.9%	13.5%	12.6%
10	Precalculus I	52.1%	3.2	2.2	1.0	0.3%	17.4%	17.1%
12	Introduction to Computer Applications and Concepts	43.4%	3.6	2.5	1.0	0.7%	16.5%	15.8%
13	United States History II	41.7%	3.4	2.5	0.9	0.0%	12.3%	12.3%
14	Calculus with Analytic Geometry I	41.1%	2.9	2.3	0.6	1.1%	16.9%	15.8%
15	Precalculus II	36.0%	3.0	2.3	0.7	0.0%	13.3%	13.3%
16	Calculus with Analytic Geometry II	31.8%	3.0	2.5	0.5	1.5%	11.9%	10.4%
17	History of Western Civilization I	31.0%	3.4	2.3	1.1	0.0%	18.1%	18.1%
18	Introduction to Sociology I	30.4%	3.6	2.6	1.0	0.0%	12.5%	12.5%
19	Introduction to Speech Communication	29.3%	3.7	2.7	0.9	0.5%	12.0%	11.5%
21	Introduction to Computing	28.5%	3.5	2.4	1.1	1.1%	17.8%	16.7%
20	Lifetime Fitness and Wellness	28.5%	3.7	2.7	1.0	1.1%	12.7%	11.6%
22	Introduction to Philosophy I	27.1%	3.4	2.4	1.0	1.7%	16.6%	14.9%
23	General College Physics I	26.2%	3.1	2.3	0.8	0.6%	14.9%	14.3%
24	Statistics	25.9%	3.3	2.3	1.0	1.8%	15.5%	13.7%
25	Introduction to Psychology II	24.3%	3.6	2.8	0.8	0.6%	9.1%	8.5%
	Overall Mean		3.3	2.5	0.9	0.7%	14.0%	13.3%

Of the credentials completed by students who took College Chemistry I, the 10 most common were two science associate degrees (the AS in Science described above and an AA&S in Science), two general studies associate degrees, an arts and sciences associate degree, an engineering associate degree, two business associate degrees, a social science associate degree, and a general education certificate. The science and engineering students had higher average grades than students who received any of the other credentials, except for the AA&S. This suggests that students who did relatively

poorly in this chemistry obstacle course may have lowered their expectations and therefore attempted and completed a relatively less competitive credential.

Following a similar pattern, the non-completers had much higher failure rates than the completers of the AS in Science. Again, many introductory courses in this program had failure rates comparable to those of introductory math and English.

Table 5 shows the top courses taken by completers of the AS in Business Administration, a transfer degree. Students in this program tended to have a much more specific focus than students in liberal arts programs. They focused on subjects such as accounting, economics, computers, and business. Completers of this program enrolled in economics and accounting courses at very high rates, since these courses are required for the degree. Those completers for whom we did not have data on one or both of these courses likely completed the missing course or courses at another institution and transferred the credits in, as is probably the case for other required courses that were not apparent in our data. The gaps in mean grades between completers and non-completers were similar to those in Tables 1 and 3, about 0.7 for liberal arts program students. The differences in the failure rates were also similar. Thus, introductory business courses, notably accounting and economics, but also computers, business, and statistics, were serving as obstacles to completion in this field.

Table 6 shows the top courses completed by degree recipients of the AAS in Nursing, a program that prepares students to take the licensure exam to become a registered nurse. This degree is even more specialized than the business degree, in that more of the courses on this list are specific to the biomedical field and fewer liberal arts courses are required.

Table 5
Completers of the Associate of Science in Business Administration, Enrollment Rate and Comparison of Grades with Non-Completers

		Enrollment Rate	Mean Grade			Failure Rate		
Rank	Course Title	Completers in this Field	Completers in this Field	All Non-Completers	Difference	Completers	Non-Completers	Difference
1	Principles of Accounting II	93.7%	3.0	2.5	0.5	0.2%	10.3%	10.1%
2	Principles of Microeconomics	91.4%	3.1	2.5	0.6	0.6%	12.5%	11.9%
3	Principles of Macroeconomics	89.6%	3.0	2.3	0.7	0.2%	16.0%	15.8%
4	Principles of Accounting I	89.1%	3.1	2.1	1.0	0.9%	22.5%	21.7%
5	College Composition II	88.8%	3.1	2.6	0.5	0.4%	10.7%	10.3%
6	College Composition I	83.2%	3.1	2.5	0.7	0.5%	14.0%	13.4%
7	Introduction to Computer Applications and Concepts	81.3%	3.5	2.5	0.9	0.2%	16.5%	16.3%
8	Precalculus I	74.2%	2.9	2.2	0.7	0.8%	17.4%	16.6%
9	Introduction to Business	73.4%	3.3	2.3	1.0	0.2%	17.8%	17.6%
10	College Success Skills	61.8%	3.6	2.8	0.7	0.5%	12.1%	11.6%
11	United States History I	59.3%	3.2	2.3	0.8	0.8%	15.7%	15.0%
12	General Biology I	57.0%	2.9	2.1	0.8	0.8%	16.3%	15.5%
13	General Biology II	50.8%	2.9	2.4	0.4	0.9%	9.0%	8.1%
14	Applied Calculus I	49.0%	2.8	2.3	0.4	1.8%	14.4%	12.6%
15	Lifetime Fitness and Wellness	45.5%	3.5	2.7	0.8	0.3%	12.7%	12.4%
16	Introduction to Psychology I	41.7%	3.2	2.4	0.8	1.2%	15.3%	14.1%
17	Principles of Public Speaking	39.7%	3.4	2.6	0.7	0.6%	13.5%	12.8%
18	Introduction to Speech Communication	39.2%	3.5	2.7	0.7	0.2%	12.0%	11.8%
19	United States History II	36.9%	3.2	2.5	0.7	0.7%	12.3%	11.6%
20	Applied Calculus	33.5%	2.8	2.3	0.5	0.0%	15.3%	15.3%
21	History of Western Civilization I	31.9%	3.1	2.3	0.8	0.8%	18.1%	17.3%
22	Statistics I	26.3%	3.0	2.4	0.6	2.2%	12.9%	10.7%
23	Probability and Statistics for Business and Economics	23.9%	3.0	2.3	0.7	0.3%	16.8%	16.5%
24	Survey of American Literature I	21.6%	2.9	2.5	0.4	0.9%	10.6%	9.8%
25	Statistics II	17.9%	3.2	2.7	0.5	1.1%	6.9%	5.9%
	Overall Mean		3.1	2.4	0.7	0.7%	14.1%	13.4%

Table 6
Completers of the Associate of Applied Science in Nursing,
Enrollment Rate and Comparison of Grades with Non-Completers

		Enrollment Rate	Mean Grade			Failure Rate		
Rank	Course Title	Completers in this Field	Completers in this Field	All Non-Completers	Difference	Completers	Non-Completers	Difference
1	Dimensions of Professional Nursing	77.4%	3.7	3.6	0.1	0.0%	0.4%	0.4%
2	College Composition I	66.3%	3.5	2.5	1.0	0.0%	14.0%	14.0%
3	Human Anatomy and Physiology II	59.3%	3.1	2.5	0.7	0.2%	8.5%	8.3%
4	College Composition II	58.9%	3.5	2.6	0.9	0.2%	10.7%	10.4%
5	Health Assessment	58.6%	3.4	2.9	0.5	0.0%	3.3%	3.3%
6	Human Anatomy and Physiology I	55.2%	3.2	2.1	1.1	0.8%	19.6%	18.8%
7	Developmental Psychology	52.8%	3.5	2.6	1.0	0.0%	13.4%	13.4%
8	Introduction to Computer Applications and Concepts	47.8%	3.7	2.5	1.1	0.0%	16.5%	16.5%
9	Nursing I	39.1%	2.7	2.1	0.6	0.0%	6.1%	6.1%
10	Drug Dosage Calculations	38.6%	3.3	2.7	0.6	0.0%	10.3%	10.3%
11	Principles of Sociology	34.7%	3.5	2.4	1.0	0.4%	14.2%	13.8%
12	Medical Terminology I	30.5%	3.6	2.5	1.1	1.4%	16.9%	15.4%
13	Second Level Nursing Principles and Concepts	29.3%	2.6	2.3	0.3	0.5%	3.4%	3.0%
14	Principles of Pharmacology I	26.4%	3.1	2.4	0.6	0.6%	11.3%	10.7%
15	Second Level Nursing Principles and Concepts II	26.1%	2.7	2.6	0.2	0.0%	0.0%	0.0%
16	Nursing II	25.5%	2.8	2.5	0.3	0.0%	2.8%	2.8%
17	College Success Skills	23.8%	3.7	2.8	0.9	0.6%	12.1%	11.5%
18	Psychiatric/Mental Health Nursing	23.5%	3.2	3.0	0.2	0.0%	1.6%	1.6%
20	College Success Skills	22.7%	3.5	2.6	0.9	0.0%	3.3%	3.3%
19	Principles of Pharmacology II	22.7%	2.9	2.8	0.1	1.3%	16.9%	15.6%
21	Health Science II	22.4%	3.2	2.7	0.5	0.6%	6.3%	5.6%
22	Health Science I	21.4%	3.2	2.4	0.8	0.0%	13.6%	13.6%
23	Nursing Organization and Management	21.1%	3.4	3.4	0.0	0.0%	0.0%	0.0%
24	Introductory Microbiology	20.8%	3.4	2.6	0.8	0.0%	8.1%	8.1%
25	Essentials of Maternal/Newborn Nursing	20.8%	2.9	2.5	0.3	0.0%	1.5%	1.5%
	Overall Mean		3.3	2.6	0.6	0.3%	8.6%	8.3%

Several introductory courses, such as Human Anatomy and Physiology and Developmental Psychology, served as obstacles to completion, as is reflected in the grade gaps for each of these courses and the differences in the failure rates (although, on average, the failure rates were lower in these courses than what we have seen for the other awards we have discussed so far). The average difference in mean grades between

completers and non-completers is slightly less than we have seen so far, around 0.6. The non-completers who took these nursing-related courses are probably students who focused on nursing or its prerequisites but who made varying amounts of progress toward the credential.

Table 7 shows the top courses completed by degree recipients of the AAS in Information Systems Technology. This is not a transfer degree, so the number of liberal arts courses on the list is minimal. The main non-computer courses on the list are two English composition courses, several business courses (including economics and accounting), and a math course. This indicates that many students in this program attempted to increase their business knowledge while they specialized in information technology.

The mean grade gap between completers and non-completers was relatively high, especially for such core courses as Introduction to Computer Applications and Concepts (a gap of 1.1), Software Design (again, 1.1), and Microcomputer Operating Systems (1.0), which indicates that the non-completers were struggling in these courses and that these courses constituted barriers to progress in and completion of this award. This was also reflected in the high failure rates for non-completers, some of which were higher than 20 percent; the average failure rate for non-completers in these courses was 16.8 percent, as opposed to only 0.6 percent for completers.

We have seen that there are obstacle courses in each program and that the particular list of courses varies by program. The extent to which a course is an obstacle also varies, as measured by the differences in average grades and failure rates between program completers and non-completers. Thus, for educators concerned with these particular programs, rather than focusing primarily on just math and English, taking action to improve student performance in this relatively broad set of obstacle courses associated with particular programs would likely have an effect on completion of those programs, although we do not have evidence of a causal relationship.

Table 7
Completers of the Associate of Applied Science in Information Systems Technology, Enrollment Rate and Comparison of Grades with Non-Completers

		Enrollment Rate	Mean Grade			Failure Rate		
Rank	Course Title	Completers in this Field	Completers in this Field	All Non-Completers	Difference	Completers	Non-Completers	Difference
1	College Composition I	76.6%	3.1	2.5	0.7	0.0%	16.5%	16.5%
2	Introduction to Computer Applications and Concepts	59.7%	3.6	2.5	1.1	0.7%	20.6%	19.9%
3	Web Page Design I	58.1%	3.4	2.5	0.9	2.1%	10.7%	8.5%
4	College Composition II	56.5%	2.9	2.6	0.3	0.8%	24.7%	24.0%
5	Software Design	53.2%	3.3	2.1	1.1	0.0%	17.8%	17.8%
6	Introduction to Business	52.8%	3.2	2.3	0.9	0.8%	17.1%	16.3%
8	Introduction to Network Concepts	47.6%	3.2	2.6	0.6	1.7%	19.2%	17.5%
7	Java Programming I	47.6%	3.2	2.5	0.7	0.9%	12.1%	11.2%
9	College Success Skills	46.0%	3.5	2.8	0.6	1.8%	22.5%	20.7%
10	Principles of Accounting I	44.4%	2.8	2.1	0.7	0.0%	14.4%	14.4%
11	Personal Computer Hardware and Troubleshooting	41.5%	3.6	2.6	1.0	0.0%	17.0%	17.0%
12	Microcomputer Operating Systems	36.3%	3.4	2.4	1.0	1.2%	24.8%	23.7%
13	Visual Basic.NET I	34.3%	3.1	2.1	1.0	0.0%	19.4%	19.4%
14	Introduction to Information Systems	31.9%	3.5	2.3	1.1	1.3%	16.0%	14.7%
15	Principles of Macroeconomics	31.0%	2.9	2.3	0.6	0.0%	18.7%	18.7%
16	Survey of Economics	31.0%	3.0	2.2	0.8	0.0%	15.8%	15.8%
17	Network Security Basics	29.8%	3.3	2.5	0.8	0.0%	15.7%	15.7%
18	Desktop Database Software	29.4%	3.4	2.5	0.9	0.0%	10.7%	10.7%
19	Windows XP Professional	28.2%	3.4	2.4	1.0	0.0%	14.6%	14.6%
20	Systems Analysis and Design	28.2%	3.4	2.5	0.9	0.0%	16.0%	16.0%
22	Web Page Design II	26.6%	3.5	2.7	0.9	0.0%	16.1%	16.1%
21	Introduction to Telecommunications	26.6%	3.5	2.5	1.0	0.0%	11.9%	11.9%
23	Windows 2003 Server (SER)	26.2%	3.1	2.4	0.7	1.6%	15.1%	13.5%
24	Mathematics for the Liberal Arts I	25.4%	2.8	2.3	0.5	1.6%	15.7%	14.1%
25	United States History I	24.6%	3.0	2.3	0.6	1.6%	15.7%	14.1%
	Overall Mean		3.2	2.4	0.8	0.6%	16.8%	16.1%

4. Estimating the True Grade Gaps Between Completers and Non-Completers

There are likely to be key differences between completers and non-completers that are related to the differences in their grades. We have data on basic demographics, including each student's sex, race, and age. While we also have students' test scores, at least one score is missing for 38 percent of the students. As a result, instead of using test scores, we used information about whether or not they enrolled in a developmental math or English course; students who do so tend to have lower test scores, since test scores are typically used to determine placement into such courses.

Some of the differences between the two groups are clearly associated with completion. For instance, White students completed at a higher rate (13.2 percent) than did Black (6.5 percent) and Hispanic students (7.3 percent), and at a slightly higher rate than Asian students (11.6 percent). Female students completed at a higher rate (12.0 percent) than male students (9.6 percent). If students enrolled in either developmental English or math, they were less likely to graduate. If they just enrolled in developmental English but not developmental math, they graduated at a rate of 9.6 percent; if they just enrolled in developmental math but not developmental English, they graduated at a rate of 10.5 percent; if they enrolled in both, their graduation rate was 6.9 percent. Students who took no developmental courses graduated at a rate of 13.6 percent. The overall graduation rate for all students was 11.0 percent.

Female students received higher grades in courses than did male students; these higher grades were associated with their higher completion rates. And White students also had higher grades than Black and Hispanic students, again, associated with higher completion rates.

The differences probably matter more near the bottom of the grade distribution. If, for example, the GPA differences between two groups are 0.4, the difference between a GPA of 1.8 and one of 2.2 is probably a bigger obstacle to graduation than the difference between a GPA of 2.8 and one of 3.2, although those with a 2.8 GPA probably graduate at a lower rate than those with one of 3.2. However, those with a GPA of 1.8 have an extremely low graduation rate (2 percent of those in our sample with this GPA graduated).

To understand the residual grade gaps between completers and non-completers that are not explained by student characteristics, we built a mixed effects model with which we predicted the difference in grades between the two groups. A mixed effects model is a combination of a fixed effects model and a random effects model. The random effects component of the model is necessary because we have multiple observations per student (multiple courses with multiple grades), and these grades tend to be correlated with one another for any particular student. In the random effects model, the deviation of any student in terms of her grades from the norm is modeled as a random variable. This model is non-causal, because completion actually occurs after grades are awarded, and this model predicts the grades based on whether a student completes.

We looked at the group of students who received a regular letter grade (A–F) in the top 100 most enrolled courses. In order to arrive at a group of non-completers that was more similar to the completers, we restricted the sample to those students who earned at least 60 credits, theoretically enough to earn an associate degree. As a result, this group, which contained 35,721 students, persisted considerably more than average.

We controlled for receipt of a Pell grant, whether or not they took college courses in high school (dual enrollment), their age, sex, race, whether or not they took remedial math and English, whether or not they intended to transfer, what entering cohort they started in, what college they attended, and the term of attendance in which they took a given course, and we employed dummy variables for attempting each of the 100 courses (less one). These course-level dummies allowed us to adjust for the fact that different courses have different mean grades.

We also interacted completion status with remedial status, so the model could account for the differences between those completers who took remediation, those non-completers who took remediation, and the corresponding two groups that did not take remediation. We had two dummy variables, whether or not a student ever took remedial math and whether or not he or she ever took remedial English, as well as a dummy as to whether he or she ever completed a credential. We formed the product of the completion dummy variable with each of the remediation variations. There was a random effect for each student that accounted for the fact that we had panel data (multiple grades per student) and that students tend to have grades that are correlated with one another.

Using this model, we found, not surprisingly, that completers still had grades that were systematically higher even after accounting for all of these controls. The difference was about 0.3 grade points (with a standard error of 0.01 grade points), which is substantially less than the 0.6 to 0.8 descriptive values that we found above. The effects of the interaction between completion and developmental status were very close to zero, and in the case of English, not significantly different from zero. This means that the model did not find any difference between completers who took remediation and those who did not, and it also did not find such a difference with respect to non-completers.

Thus even when we adjusted for observed differences between completers and non-completers and restricted to comparable groups of students in terms of credits earned, there was still a gap in grades associated with completion, although it was substantially reduced. This gap is closer to an estimate of the "true" gap. The fact that the gap still exists after these adjustments indicates that colleges can work to potentially reduce the gap, which would thus influence completion, at least in theory. The larger gap obtained through descriptive observations may be more salient for educators, as that is the gap they would actually be faced with overcoming.

5. Examining the Relative Effects on Completion of Gatekeeper English and Math and Other Commonly Taken Introductory Classes

5.1 Comparing Obstacle Courses to Introductory Math and English in Pairs

Earning higher grades in both gatekeeper math and English courses and in obstacle courses outside these subjects is associated with an increase in one's chances of completion. In each case, we considered subsets of students who took pairs of courses—one math or English course and one introductory course outside these subjects—and ascertained the relative effects of doing well in each subject. This allowed us to estimate whether success in gatekeeper math or English appears to be more important than the other courses in predicting ultimate success. To do so, we considered the two most frequently taken gatekeeper English and math courses, which were College Composition I and Precalculus I respectively.

The obstacle courses most frequently taken with College Composition I, outside of English and math, were General Biology I and Introduction to Computer Applications and Concepts. For Precalculus I, they were General Biology I and United States History I.

For each of these four pairs of courses, we considered the students who took that pair and examined the effect of the pair on their chances of completing any credential by running a logistic regression with binary completion as the outcome, the grade in each course as a predictor, and controlling for each student's race, sex, age, cohort of entry, Pell grant receipt, transfer intent, enrollment in remedial math and English, and college attended. For each course's grade, we arrived at an odds ratio estimate, which is the factor by which the odds of completion increases per unit increase in a student's grade.[5]

In each of the four cases, the point estimate of the odds ratio (affecting the odds of completion) associated with gatekeeper math or English was not significantly different from that associated with the other subject course. Thus we have no evidence that math or English has any greater association with success than the course each is paired with, in the two pairs for math and two for English. The details are shown in Table 8. Each grade point increase in each course was associated with an increase in the odds of completion of about 1.4 to 1.6.

Table 8
Logistic Regression Estimates of the Relationship Between Grades in Pairs of Introductory Classes, Where One of the Pair is Math or English, and Completion

	Course	Odds Ratio	Standard Error	95% Confidence Interval	
Regression 1	College Composition I	1.49	0.03	1.44	1.54
(*n* = 31,124)	General Biology I	1.57	0.02	1.53	1.63
Regression 2	College Composition I	1.58	0.02	1.54	1.63
(*n* = 41,683)	Introduction to Computer Applications and Concepts	1.58	0.02	1.53	1.62
Regression 3	Precalculus I	1.36	0.03	1.30	1.42
(*n* = 11,227)	General Biology I	1.46	0.04	1.40	1.54
Regression 4	Precalculus I	1.43	0.03	1.37	1.49
(*n* = 11,511)	United States History I	1.46	0.04	1.39	1.54

[5] For instance, if the odds of completion was 1:3 (p = .25) if a grade in a particular course was a B, and the odds ratio was 2, an increase to an A would boost the odds to 2:3 (p = .5).

There is no claim of causality here; these relationships are simply observed associations. For instance, a student's grade in any one of these courses may be a function of other unobserved student characteristics, such as motivation or ability, which are in part based on having learned to succeed academically in earlier educational experiences. The moderately strong correlations between the grades in these courses lend credence to the idea that unobserved student characteristics are playing a role. This is not surprising, since students who do well in some courses tend to do well in others. The pairwise correlations ranged between .37 to .46.

The five courses under consideration here often form part of a liberal arts program. For instance, the liberal arts degree at one community college in the system under consideration requires the composition course (and the one following it), two history electives (one of which may be the history course above), either Math for the Liberal Arts or Precalculus I as above, and two science electives (biology was the subject that was most typically taken). The computer course is not required, but is also commonly taken.

We also ran a logistic regression that included four of these five courses (all but the computer course, which is not required for the liberal arts degree) as predictors of completion for the 6,349 students who took all four courses. The odds ratios associated with completion for math, English, biology, and history were 1.25, 1.37, 1.34, and 1.20 respectively. These estimates were not, however, significantly different from one another. It is interesting that the grade in math is no more predictive of success than the others, despite the common belief that math is the largest barrier to eventual completion. Of course, this group is restricted to only those who actually attempted the math course; "math anxiety" may cause students to never actually enroll in math. Another possibility is that those who take math may be more capable at it.

Most students at community colleges pursue a liberal arts program. Since such a program has quite a few distributional requirements, including math, English, social science, history, science, and humanities, there is no particular reason to privilege math and English over the other requirements as barriers to completion. While the typical

program may encourage students to take math and English early in their careers, not all students do this; they often take introductory courses in other subjects early as well.

We do not have program-level data on students after they transfer, for those students who do so. All we know is whether they transferred or not and whether they earned a bachelor's degree, although the field of the degree was seldom specified. However, we can speculate that a grade in an introductory subject course is predictive of whether or not a student ultimately completes a major in that subject at a four-year college. We would like to obtain data that would allow us to explore this issue.

Our results for business and nursing courses were similar to those for liberal arts. In each case, we looked at a subject course and a gatekeeper course, and found no significant differences in the odds ratios between the two.

5.2 Comparing Patterns of Success in Introductory Courses

Another way to compare the effects of doing well in introductory courses is the following. Consider two courses. One can do well in both of them, in just the first one, in just the second one, or in neither. Here, we define doing well as earning a grade of B or higher in the course. We considered two pairs of courses along these lines: Precalculus I and General Biology I, and College Composition I and United States History I. For each pair, we considered students who took them concurrently in their first semester of enrollment.

In the case of the first pair, we found that predictively, ultimately doing well in both was not significantly different from doing well in the biology course alone, while doing well in both was significantly different from doing well in the math course alone. For these students, success in math alone was less of a predictor of ultimate success than success in biology alone was, indicating that perhaps biology is a "hard course," success in which is correlated with ultimate completion, while math is less so. Here, the odds ratios were 6.0 for success in both, 1.7 for success in math only, and 5.0 for success in biology only.

The story for the second pair is somewhat different. In that case, doing well in both was significantly different from doing well in English alone, and also significantly different from doing well in history alone. The corresponding odds ratios were 6.9, 3.4,

and 2.8. However, doing well in English alone was not significantly different from doing well in history alone.

By comparing students who did well in only one subject with each other and with those who did well in both, we are able to get a better sense of which course it is more important to do well in, and we found that gatekeeper courses alone (without higher performance in the paired course) were never statistically significantly superior predictors to equivalent performance in the paired course alone.

To summarize, we have quantitatively demonstrated in this section that math and English, while important, do not have any stronger relationship with completion than do other introductory courses. This reinforces our thesis that educators and policymakers need to pay attention to a broader range of courses in their efforts to improve community college completion rates.

6. Modeling the Relationship Between Introductory Course Grades and Completion

To get more robust estimates of the relationship between course grades in introductory courses and ultimate completion, we also estimated propensity score models (PSMs). We used these models to compare each "treated" student with a weighted set of non-completers who have closely matched attributes.

Here, the treatment is whether or not the student passed a given course in his or her first term in college. We restricted to the first term because we wanted the treatment (taking the particular course) to be definitely prior to the outcome (completion). The estimate of the treatment effect is simply the mean difference in outcome between the treated students and the matched untreated students.

In computing the propensity score, we used whether or not students received a Pell grant, whether they took one or more dual enrollment courses while in high school, their age on entering college, their race, whether they planned to transfer, whether or not they enrolled in remedial math in their first term, the same for remedial English, what college they attended, and what cohort they were in, as well as interactions between race and sex, race and age, and age and sex.

We obtained good balance and excellent overlap in all of our propensity score models. By balance, we mean that the comparison group was similar to the treated group on observed characteristics; by overlap, we mean that the two distributions of propensity scores for the treated and non-treated groups have a high degree of overlap. Both of these are necessary for a successful PSM.

The seven courses we considered were all frequently taken courses that we considered earlier in this paper: Precalculus I (gatekeeper math), General Biology I, College Composition I (gatekeeper English), United States History I, Introduction to Computer Applications and Concepts, Introduction to Business, and Human Anatomy and Physiology I.

For each course, we estimated five models: one PSM and four regressions. The four regressions were: an unweighted logistic regression, an unweighted OLS regression, a weighted logistic regression, and a weighted OLS regression. Since the outcome here was whether or not a student completed a credential, the OLS models were both linear probability models. The controls used in these models were the same as those used to estimate the propensity score for the PSM. The weights for the two weighted regression models were obtained from the PSM. We estimated all of these models in order to know how sensitive our results were to different model specifications.

And, as is shown in Table 9, the results were very robust to these different model specifications. The estimates of the differences in the probability of completion given by the PSM model and those given by the two linear probability models, in the case of all seven courses, were very close, and those of the two latter models were statistically identical. The range of these probability difference estimates was .11 to .17 across all of these courses, indicating that passing each course was associated with a similar boost in their chances of graduating, irrespective of which course it was.

We repeated this exercise with a “treatment” of earning a grade of B or better in these introductory courses, and the results are shown in Table 10. The story is quite similar; here the estimates ranged between 0.10 and 0.15. Getting good grades—As or Bs—seems to have a significant association with a student’s chance of graduating.

Table 9
Estimated Effects (Non-Causal) of Passing Introductory Courses in the First Term on Completion, Using Logistic, Linear Probability, and Propensity Score Models

	Unweighted Estimates				Treatment Effect from PSM (ATT)		Regression Estimates with PSM Weights			
Course	Logistic Odds Ratio	S.E.	Linear Prob. Model	S.E.	Estimate	S.E.	Logistic Odds Ratio	S.E.	Linear Prob. Model	S.E.
Precalculus I	4.31	0.55	.15	.01	.17	0.02	5.25	1.13	.17	.01
General Biology I	7.10	0.99	.14	.01	.14	0.01	5.85	1.10	.13	.01
College Composition I	7.78	0.59	.12	.00	.12	0.00	7.74	0.83	.12	.00
United States History I	6.82	0.79	.13	.01	.14	0.01	7.77	1.27	.14	.01
Introduction to Computer Applications and Concepts	10.97	1.55	.11	.01	.13	0.00	12.28	2.37	.13	.00
Introduction to Business	11.12	2.66	.11	.01	.13	0.01	15.96	5.78	.13	.01
Human Anatomy and Physiology I	4.41	1.09	.12	.02	0.13	0.03	7.31	2.03	.13	.02

Table 10
Estimated Effects (Non-Causal) of Obtaining a Grade of B or Better in Introductory Courses in the First Term on Completion, Using Logistic, Linear Probability, and Propensity Score Models

	Unweighted Estimates				Treatment Effect from PSM (ATT)		Regression Estimates with PSM Weights			
Course	Logistic Odds Ratio	S.E.	Linear Prob. Model	S.E.	Estimate	S.E.	Logistic Odds Ratio	S.E.	Linear Prob. Model	S.E.
Precalculus I	2.27	0.18	.12	.01	.14	0.01	2.79	0.29	.14	.01
General Biology I	3.05	0.20	.13	.01	.13	0.01	3.17	0.29	.13	.01
College Composition I	3.41	0.12	.11	.00	.11	0.00	3.65	0.19	.11	.00
United States History I	3.46	0.19	.13	.01	.13	0.01	3.44	0.28	.12	.01
Introduction to Computer Applications and Concepts	4.82	0.32	.11	.00	.12	0.01	4.72	0.49	.12	.01
Introduction to Business	3.74	0.38	.10	.01	.10	0.01	3.58	0.50	.11	.01
Human Anatomy and Physiology I	3.62	0.63	.13	.02	.14	0.03	4.48	1.09	.15	.02

These propensity score models, since they are largely non-parametric (they simply look at mean differences between matched cases), are not sensitive to the functional form, as a regression would be. The PSMs can construct a good comparison group when there is good overlap and balance (which we do have in this case). Therefore, we can be more confident that the estimated associations of student performance and completion are at least independent of the characteristics that we have measures of and

which we have achieved balance on and/or have controlled for. We still cannot say that these estimates of relationships between grades and the completion rates are causal, but we have taken a step in that direction.

Consistent with the analyses provided in this paper, all of these models, including the PSM models, indicate that gatekeeper math and English appear to have relationships with completion that are no larger (or smaller) than those found for the other five courses we have examined. Given that the PSM methodology is more robust than the other regression-based methods and that all of these methods yielded similar results, it appears that our results overall are robust.

7. Student GPA and Completion

To put the relationship between higher grades in individual courses and completion rates, as described above, in context, we also considered the relationship between a student's GPA and their chances of completion. We created a logistic regression model of the relationship between a student's GPA in all of their college-level courses and whether or not they completed a credential, using the same controls as in the models described above, for all students who took at least one college course. The model contained 156,299 student observations.

We found that there was a very strong relationship between GPA and the chances of completion. Every increase of one grade point in GPA increased the odds of completion by a factor of 4.7; this odds ratio was highly significant ($p < .001$). Overall, descriptively, completers had a mean GPA of 3.1, and non-completers had a GPA of 2.1. The overall completion rate was 11 percent.

When we limited ourselves to looking at the top 100 courses taken by all students, which was roughly the group of courses we observed in this study, and examined each student's GPA in just those courses, the relationship between GPA and completion was still strong, although not as strong. The odds ratio associated with the GPA was now 3.0, with a very low *p* value ($p < .001$). The model now contained 142,789 observations. This decreased relationship makes sense, because the GPA for these 100 courses does not measure consistent performance over as many courses as the complete GPA. However,

this analysis indicates that most of the increase in the odds of completion associated with an increase in GPA is due to doing well in these top courses, which is another way of understanding how important those courses are.

Thus, the relationship between GPA and completion appears to be much stronger than the relationship between a grade in any single course and completion. Above, we found odds ratios associated with individual courses that were between 1 and 2; they were highly significant but lower in magnitude than the 4.7 we found for GPA.

It is not surprising that GPA is more strongly associated with completion; after all, a higher GPA means higher *consistent* performance across a range of courses, as opposed to just a single course, and for most students this involves the ability to balance the demands of multiple courses at the same time. This means that community college faculty, staff, and administrators need to pay attention to GPA as an important ultimate predictor of student success in addition to performance in individual gatekeeper/obstacle courses, broadly construed.

8. Conclusion

In this paper, we examined the extent to which introductory courses in subjects other than math and English served as barriers to community college completion. Despite the focus on college math and English, we found that many introductory college-level courses in other subjects also served as obstacles to completion for many students, and these latter courses posed obstacles just as great as college math and English.

Although some have argued that math and English skills are necessary for success in other subjects and are therefore more fundamental, others have argued that these courses simply have the effect of screening out less-prepared students by placing many students in developmental math and English courses. In a study of one community college system, Scott-Clayton and Rodriguez (2012) found that such courses did not promote student learning but rather simply diverted students from taking college-level courses. While this paper does not address that question in particular, we found that success in gatekeeper math and English is no more associated with completion than is success in the other courses.

While examining course failure rates is a method commonly used by community college institutional researchers to identify courses that students are having difficulty in, looking at grade gaps in a given course between program completers and non-completers is a novel method that provides a sense of the importance of these courses for completion. The observed performance of completers could serve as a reasonable target for students who have not yet completed.

This paper described two methods for identifying courses that serve as obstacles to completion. Among those courses most taken by completers, we compared the failure rates of non-completers and the grade gaps between completers and non-completers. Both of these methods are useful in determining the extent to which a given course is an obstacle, and both can be used by colleges that want to identify the main obstacles at their own institutions. We also presented methods for assessing the relative extent to which different courses are obstacles, so that colleges can decide on where to target their energies in reducing these obstacles.

Completers did much better than non-completers in obstacle courses (including introductory math, English, and other introductory courses), in terms of both higher grades and lower failure rates. Even when we adjusted for observed differences between completers and non-completers, the performance gaps between completers and non-completers remained, indicating that there were differences between the two groups that we have not observed and therefore could not control for.

It is not surprising that the association between success in introductory math and English and completion, while strong, is no stronger than that for the other obstacle courses we identified. This makes sense, because a given student's grades tend to be correlated with one another. Grade differences between students are not the ultimate cause of success; rather, grades are simply reflections of student attributes and behavior. A grade in any given course, whether it be math, English, psychology, biology, or history, is likely to reflect a student's motivation, amount of time he or she invests in school, mastery of learning strategies, ability to multitask, overall time management skills, and his or her level of prior learning, among other attributes. In a sense, the grade in any given course may be a proxy for these other things, which may be more fundamental to success than the acquisition of knowledge and skills. It is therefore not

surprising that we found overall GPA to be an even better predictor of completion than grades earned in individual courses, since it measures a student's ability to apply these qualities and skills in multiple courses.

If colleges want to improve students' chances of completing a credential, they should consider attending to student performance in a broader set of courses beyond college math and English alone. These other courses are important parts of the pathways that lead to completion of programs in one or more fields. This suggests that colleges should consider broadening the focus of college remedial instruction, which is generally confined to preparing students for success in college-level math and English.

One way that colleges have tried to address these various components to success is through "student success courses," which promote students' academic and non-academic skills and are required in the state system under study. Colleges can also help by providing both academic and non-academic student services, such as tutoring and counseling.

Colleges can use our methods to identify obstacle courses, and then monitor the performance of students in these courses to identify those who are struggling to help get them back on course toward completion before it is too late. They can also identify students who did well in these courses and yet dropped out anyway, and reach out to them to try to get them back on track to completion. These latter students may be the "low hanging fruit" of the completion agenda, since they have already shown that they can succeed in college-level courses.

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