# Crossing the Boundaries:

# STEM students in four-year and community colleges*

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## Introduction

Four-year colleges and universities play a central role in educating the nation's scientists and engineers. Community colleges play a key role in educating technicians who comprise the "T" category in STEM and providing the first two years of education to science and engineering students who transfer to community colleges. Aside from these commonly recognized roles, what is often overlooked is the movement to community colleges by students who begin their STEM education in four-year colleges and universities.

In this paper we consider the role of community colleges for four-year STEM students as they move through their educational careers. We examine a student cohort who began their freshman year at a four-year college and the pathways that lead them to coursetaking or degrees at a community college. We identify three distinct roles of community colleges as used by four-year college students: (1) reverse transfer; (2) supplemental course taking while pursuing a four-year degree; (3) post-graduate community college coursetaking and/or enrollment. There are other variations on these three basic patterns but limited data and sample size constrain our analysis to these broader patterns.

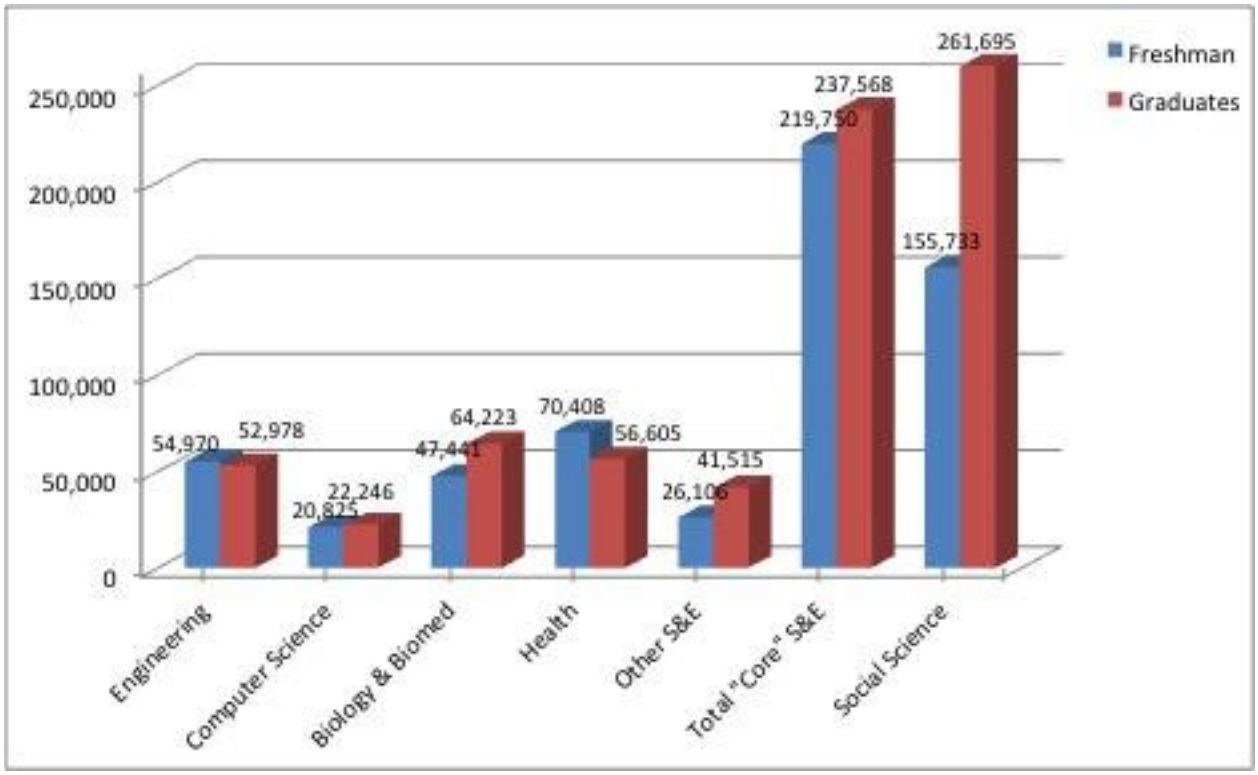
This initial analysis finds community colleges are an important education and training pathway into the STEM workforce, either directly or by way of entry into a four-year college. The dual role of community colleges for four-year students is one of a supplement or complement to their four-year degree (for concurrent enrollment/coursetaking and/or post-grad courses or certificates) and, for others, as an exit pathway through reverse transfer that can lead to an alternative education and workforce entry route through a two-year degree or certificate; however, the reverse transfer route also appears to be just a way station for some four-year students as they stop out of post-secondary education altogether. The two-year, reverse transfer alternative pathway for four-year students may be a positive option for those who find four-year schools a bad fit for their educational and/or career interests, are ill-prepared for a four-year degree, or otherwise seeking an alternative post-secondary option. Unfortunately, it also appears to be a post-secondary exit route that mirrors the race and class disadvantages in the overall education system. Understanding these different functions of two-year colleges for four-year students could enable colleges to address problems leading to drop out for some and, for others, facilitate the complementary role of two-year colleges.

## Background

The focus in this paper on the role of community colleges for students pursuing four-year STEM degrees has emerged as a more general reconsideration of how students develop their STEM education. The prevailing notions of college STEM "production" are framed by a perspective of a "pipeline" in which there is a fixed population of high school graduates who have the academic preparation, performance, and interest necessary to pursue a STEM career. The STEM pipeline problem is defined as one of a diminishing "flow" as that population moves through the higher education system. This pipeline framework, however, suffers from a set of largely untested propositions (e.g., that there is a fixed population of STEM-eligible students that comprise the initial, freshman entry cohort; and that "flow" is unidirectional), and data limitations that have constrained the types of analyses possible. In combination, the STEM pipeline analyses tend to track only the outflow of STEM students from college entry through graduation. Further, student flows across different types of institutions, and between four-year and two-year colleges in particular, may get lost in the usual tracking of STEM students.

Recent and ongoing research suggests that the pipeline perspectives have provided only a limited analysis of the STEM pathways of college students; in particular, Salzman (forthcoming) finds that, using a new, nationally representative longitudinal dataset (with oversampling of STEM students), within the cohort of four-year students graduating within six years from entry, the size of the STEM cohort changes only slightly between freshman year and graduation. In other words, although there are large attrition rates of freshman STEM majors, there is also a large STEM *in-flow* of students who do not start their college career in STEM majors (See Figure 1, which shows the STEM population at freshman year and graduation, tracking the STEM flows of a student cohort who start and graduate from a four-year college within six years, graduating in 2008). The S&E pathway flows shown in Figure 1 do not include students who begin in a two-year college and transfer to a four-year college; thus, community colleges provide an additional source of four-year S&E graduates, as examined in Van Noy and Zeidenburg (2014).

**Number of Baccalaureate S&E Freshman & Graduates**




[From: Salzman, 2014/working paper: "Reconceptualizing Science and Engineering pathways: An empirical analysis of college student flows"]

Considering the role of community colleges in the STEM workforce leads us to consider in more detail the nature of educational pathways into the STEM workforce. As noted above, two-year and four-year pathways lead to distinctly different segments of the STEM workforce: S&E is at least a four-year degree route and technology occupations are nearly all entered through two-year or less educational routes. At the same time, there is "crossover" use of community colleges and four-year institutions by students who take courses in both institutions and those who change course by moving their enrollment between institutions.

The role of community colleges in STEM pathways may be further obscured by the very use of one category under the label "STEM" to characterize these educational and occupational groups. This singular category of STEM combines disparate occupations and educational courses of study. Especially by not distinguishing between two-year and four-year STEM degrees, the STEM label increases the opaqueness of the STEM workforce and supply analysis. In the STEM category, for example, science, engineering, and math (S&E), for the most part, occupationally require four-year and/or graduate level education and it is only technology jobs for which two-year colleges are direct suppliers. To the extent that community colleges supply the S&E workforce, it is largely through its transfer function to four-year colleges. It is this supply route

that Van Noy and Zeidenberg (2014) have analyzed and found that 25% of community college students who are ever in a STEM major[1] transfer to a four-year college and continue to pursue a STEM major, and 10% of students "ever-in-STEM" attain a bachelor's degree within 6 years. And, many more community college STEM students aspire to transfer to a four-year college and attain a bachelor's degree. Among community college students, over two-thirds report they would like to attain a bachelor's degree (Van Noy & Zeidenberg, 2014).

Community colleges may also play an important role in providing education to four-year-college STEM students in a range of other, less recognized roles. Reverse transfer is often noted as those who start in a four-year and then transfer to a two-year college for any number of reasons, ranging from financial to educational (seeking a less rigorous curriculum or a more workforce-oriented education) to logistical (closer to home; to attend part time). Townsend and Dever (1999) refer to these students as undergraduate reverse transfer students; among these students they identify two groups: those students who start at a four-year college and transfer to a 2-year college, and those students who start at a four-year college and attend a 2-year college on a temporary basis, for example, during a summer session. In addition to undergraduate reverse transfer, Townsend and Dever (1999) also identify what they refer to as post-graduate reverse transfer students who take courses for a variety of reasons after obtaining their bachelor's degree. This prior research has been limited by data availability in its ability to describe the basic characteristics of these different groups of reverse transfer students.

Recent research on reserve transfer sheds some light on the issue among the general population of four-year students. Analyses of the general four-year student population based on national data indicate that reverse transfer, where students leave the four-year institution for the community college, occurred among 14.4 percent of the population, and that enrollment just for summer courses occurred among 5.4 percent of the population (Hossler, Shapiro & Dundar, 2012). Many of the students who leave the four-year school for a community college, however, eventually return to a four-year institution, though often not at the institution in which they started (Hossler, Shapiro & Dundar, 2012). Research using national survey data to examine the effects of co-enrollment in four-year and community college found that enrollment in a community college at the same time as a four-year college has a positive relationship with bachelor's degree attainment (Wang & Wickersham, 2014).

These less recognized roles of community college for students in four-year colleges have received little attention in the context of STEM. One of the few studies—Tsapogas (2004)—provides some sense of the magnitude of these pathways. This study reports that 44 percent of bachelor's and master's degree graduates in science and engineering (S&E) fields attended

[1] "Ever-in-STEM" (or "STEM-ever") is defined as those who are enrolled in a STEM major during at least one wave of the survey or as indicated in administrative records. See methodology section below for detailed explanation.

community colleges, where S&E is defined as including computer science, math, life science, physical science, social science, and engineering. Approximately 28 percent of these students (or 12 percent of all S&E BS and MS graduates) attained associate degrees. While many students transfer without attaining an associate's degree, these data suggest that community colleges serve an important function for students in addition to being one route for completing a BS degree. Community colleges thus appear to provide an important educational and/or career role for a sizable segment of bachelors and masters graduates, and much of that education and training appears to be used outside of formal programs, not resulting in a terminal degree or certificate but seemingly a crucial adjunct to their four-year and/or masters-level education. The most common reasons reported for attending a community college were to complete credits towards a bachelor's degree (though it is not clear that this is through transfer or through concurrent coursetaking) and/or to gain further skills or knowledge in an academic or occupational field (Tsapogas, 2004).

These finding suggest a need to better understand this significant but less understood contribution of community colleges to four-year STEM education. Most importantly, we know little about the full range of different pathways that four-year STEM students follow at community college, and the types of students who follow each of these pathways.

**The Methods and Analysis**

To conduct this analysis, we use the National Center for Education Statistics' (NCES) Beginning Postsecondary Students (BPS) 2004/09 survey. The BPS survey includes a nationally representative cohort of students enrolled in postsecondary education for the first time in 2003/04 in credit bearing programs. This dataset includes a total of 16,684 students. Students were surveyed once at the end of their first academic year in 2003/04, a second time in 2005/06, and a final time in 2008/09, six years after their initial enrollment. We use the BPS restricted-use dataset, which allows access to the complete set of variables in the dataset with the provision that certain data not be reported to protect the confidentiality of respondents when there are small sample sizes. In addition to student interviews, the BPS includes transcript data from all institutions that each student attended from the 2003/04 to 2008/09 academic year. We focus this analysis on students who were initially enrolled in a four-year public or private not-for-profit institutions—a total of 8,327 students.

Defining the STEM population is, itself, not a straightforward endeavor. Historically S&E education and workforce analysis included the STEM fields of engineering, biology and biomed, computer sciences, physical sciences, math, and social sciences. It typically excluded health majors and occupations. This definition has historical roots in the data collection and analysis functions of NSF which was charged with the S&E analysis in the 1960s. In terms of more recent concerns about the overall science and technology policy and education, social sciences

often have been excluded in the definition and health included[2]. In this analysis we provide findings on the "core" STEM majors although we acknowledge the importance of health and social science majors. Because there is no consistent or clear rationale for using one STEM definition rather than another, we provide multiple breakouts to capture a broad range of STEM education and pathways.

Analysis of the role of community colleges in four-year student educational trajectories poses definitional and analytic challenges. The pathways of all students, both four-year and two-year, are often quite fluid, with about a third of ultimate STEM graduates beginning their four-year college career outside of a STEM major (undeclared or in a non-STEM major; Salzman, forthcoming). Moreover, the cohort of community college STEM students is nearly as large as the four-year STEM cohort, with 277,421 community college STEM students in a 2003/04 cohort (BPS, 2003/04), compared to about 350,000 four-year students who are in a STEM major at one point in their college career. These figures include those starting but leaving so the number is greater than just the starting and finishing cohort sizes shown in Figure 1. These factors make it difficult to define and, as a practical matter, track a "STEM major". For our analysis, we examine primarily the STEM functional role of community colleges in providing education to the four-year student population, defined as students who begin as freshmen in a four-year college.

In the BPS, we identify whether a student is in a STEM program using two data sources: student interviews and student transcripts. First, measures of students' majors for each year of the survey were collected from student interviews and supplemented with institutional information when not available from the interviews. In each of the three waves of BPS interviews (2003/04, 2006, and 2009), students were asked if they had declared a major. Those with a declared major were asked about their major or field of study. If a student did not report a major, the survey used information on the student's major as reported by their institution. Using these measures, we identify those students enrolled in STEM programs throughout their enrollment in college over the years of the survey. These data are primarily based on self-reports and best reflect students' intentions to major in a program. Second, transcript data were collected after the six-year survey follow-up. These data best reflect the majors that students officially completed, though they do not reflect changes in students' majors over time. We use student transcript data to identify the students' majors upon completion. Based on these data, we determine if a student is ever in a STEM major at any point in time during their college enrollment.

[2] Health majors are often an artifact of the idiosyncratic behaviors of colleges in offering a pre-professional health major as distinct from life science majors, though it appears that curriculum varies little if at all in terms of its science content from life science majors. However, some colleges may have additional health majors that are not science degrees (e.g., health policy) but we are not able to identify those schools in the dataset.

Tracking flows is difficult from the available data and required we use several different analytic approaches. To identify our groups of interest, we used both survey questions in the BPS and detailed coursetaking information from BPS transcript data. Using these available measures, we identify four key populations of STEM students who begin in a four-year college and then take courses or enroll at a community college in at least one of several different pathways. These pathways include the following: (1) reverse transfer—students who initially enroll at a four-year college but leave and enroll in a community college; (2) concurrent enrollees—students who initially enroll at a four-year college and also enroll in a community college while enrolled (during the regular academic year semester and/or during summer); and (3) post-graduate coursetakers —four-year students who graduate with a bachelor's degree and then take courses or enroll at a community college.

We sought to use BPS survey data when possible to identify these groups of students. For the measure of "reverse transfer" students we use the BPS survey data to identify students who had transferred from a four-year institution to a two-year institution. For the measure of "concurrent enrollment" we use the BPS survey data to identify students who began their studies at a four-year college and enrolled at a community college at some point, but were not reverse transfer students as defined by the previous measure or enrolled in a community college program after completing a bachelor's degree, as identified using BPS survey data. The limitation of the survey data is that it relies on students' reports of their enrollments rather than their individual coursetaking which may occur without enrollment. The measure of whether students enrolled in a community college program after their bachelor's degree, for example, likely suffers from this problem, since many four-year students may take courses.

In addition to the BPS survey measures, we developed measures of these groups of students using coursetaking information from BPS transcript data. We identify students who begin their coursetaking at four-year colleges and universities and who also have taken a community college course. We then compare the date of the students' last four-year college course to the date of their last community college course. We identify as "post-graduate coursetaking" those who took a community college course after their bachelor's degree. We identify as "concurrent coursetaking" those who took a community college course before their last four-year course before their bachelor's degree or their last four-year college course taken for those who did not complete a bachelor's degree. The "concurrent coursetaking" measure is related but different from the "concurrent enrollment" because of definitional differences between "enrollment" (enrolled in the institution during the regular term) and coursetaking (which can be for a single course at any time and without enrollment in the community college), and the different data sources (i.e., student survey reports versus institutional records on transcripts). We report on both measures because they each have strengths and weakness, but together they provide a comprehensive indication of the numbers of students who take courses and/or enroll concurrently at a community college while enrolled at a four-year institution.

## Findings

Community colleges provide STEM education to a large population of students, approximately two-thirds the size of the four-year college STEM population. The community college population from the 03/04 entering cohort that was ever-in-STEM in the six years after their initial enrollment (as we have defined it, above), was approximately 277,000 students. By comparison, the restricted cohort of four-year college students who entered in 03/04 and was ever-in-STEM within six years is slightly more than 400,000 students.

In this paper we consider an additional role of community colleges in providing education to four-year starting students who are in STEM at some point during their college career. Several different types of pathways are possible among four-year STEM students who later enroll in community colleges. First, the "reverse transfer" group start in a four-year college and then transfer to a community college and do not complete a four-year degree (at least within the six-year time frame of our analysis that is captured in the sampling frame of the longitudinal data). Second, four-year students may take advantage of course-taking opportunities while pursuing their four-year degree program through taking summer courses at the community college to concurrent enrollment in community courses while in a four-year program. Finally, four-year students may enroll in the community college courses or programs after receiving their bachelor's degree ("post-BA coursetaking"). The reasons for these different pathways can be varied, and within the scope of this analysis we consider only the observed behavior or coursetaking patterns and do not analyze the reasons (for which there are limited data for this population).

The population of interest, those who start in a four-year college, are in STEM at some point in their college career and take courses and/or enrolling in a community college are described in Table 1. Among the four-year STEM-ever population nearly 10 percent of the overall cohort did not complete a four-year degree and reverse transferred to a community college (this excludes those who started at a four-year college and did not complete their four-year degree and did not use a community college). Slightly more than 8 percent of all STEM-ever students enrolled concurrently in both a four-year and two-year college. If we examine all concurrent coursetaking (a broader definition which includes those who took a course at a two-year college but may not have formally enrolled in a two-year program of study), we find substantially more, nearly 19 percent, of four-year STEM-ever students also use a two-year college. Finally, also based on coursetaking, just over 5 percent of four-year graduates students take a two-year course after obtaining a bachelors degree.

| Table 1<br>Community College Attendance as a Percentage of Four-Year STEM Students | | | | | | | |
|---|---|---|---|---|---|---|---|
| Reverse transfer | | Concurrent enrollment | | Concurrent coursetaking | | Post-graduate coursetaking | |
| % | Population | % | Population | % | Population | % | Population |
| 9.8 | 40,549 | 8.3 | 34,343 | 18.6% | 77,004 | 5.3% | 22,011 |

*Background of Four-Year STEM students using Community Colleges*

The population characteristics of these students provide an overview of the potential differences in community college functions for different groups. For example, the race profile of the four-year STEM community college population is different from the racial profile of the overall four-year STEM population. What appears to be notable is the difference in community college pathways among four-year African-American students: more than twice as many of these students reverse transfer to a community college (6,371) than use concurrent enrollment (2,251) or community college coursetaking (4,843). The greater use of reverse transfer, at 16 percent of all African-American STEM-ever community college students, is both much larger than that of other ethnic/racial groups (at approximately 11 percent reverse transfers of each of the other demographic groups) and a difference in the opposite direction from other groups: other than African Americans, all other racial groups tend to have comparable or more concurrent enrollment community college coursetaking than reverse transfer. These trends should be taken as suggestive given small sample sizes, but to the extent they are reflective of actual differences, they suggest community colleges are differentially used by African-American STEM students as an alternative college pathway, with less likelihood than other groups to persist to four-year completion. Table 2 summarizes enrollment patterns by students' racial/ethnic composition.

| Table 2:<br>Racial/Ethnic Composition | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | All 4-year STEM* | | Four-Year Community College STEM Students | | | | | | | |
| | | | Reverse transfer | | Concurrent enrollment | | Concurrent coursetaking | | Post-graduate coursetaking | |
| | % | Pop. | % | Pop. | % | Pop. | % | Pop. | % | Pop. |
| White | 67% | 277,225 | 58% | 23,383 | 62% | 21,193 | 65% | 50,404 | 75% | 16,556 |
| Black/ African-American | 9% | 38,480 | 16% | 6,371 | 7% | 2,251 | 6% | 4,843 | 3% | 596 |
| Hispanic/Latino | 9% | 38,894 | 11% | 4,445 | 14% | 4,694 | 11% | 8,206 | 7% | 1,615 |
| Asian | 9% | 38,482 | 11% | 4,368 | 10% | 3,472 | 10% | 7,613 | 2% | 539 |
| All Other | 5% | 20,688 | 5% | 2,000 | 8% | 2,722 | 8% | 5,938 | 12% | 2,705 |

***** The "All 4-year STEM" population is all students who begin their first-year year at a four-year college and are ever-in-STEM during the six-year period of the survey.

Overall men use community colleges at a slightly higher rate than females, but the types of community college use diverge significantly. Notably, males have greater use of reverse transfer, suggesting that community colleges are more likely to become the alternative college pathway for males. In community colleges, these men are more likely to enroll in technician programs than are females. Table 3 summarizes the enrollment patterns by gender.

**Table 3:**
**Gender Composition**

| | All 4-year STEM | | STEM Four-year Community College Students | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Reverse transfer | | Concurrent enrollment | | Concurrent coursetaking | | Post-graduate coursetaking | |
| | % | Pop. | % | Pop. | % | Pop. | % | Pop. | % | Pop. |
| Female | 37% | 153,093 | 26% | 10,348 | 38% | 12,882 | 33% | 25,681 | 37% | 8,178 |
| Male | 63% | 260,675 | 75% | 30,219 | 63% | 21,450 | 67% | 51,323 | 63% | 13,833 |
| **Total** | 100% | 413,769 | 100% | 40,567 | 100% | 34,332 | 100% | 77,004 | 100% | 22,011 |

Further analysis of the characteristics of this population shows that, not surprisingly, all community college attendance by four-year students is more common among those with fewer financial resources as indicated by Pell Grants, first generation college student status, job holding, and hours worked. Among four-year community college pathways, reverse transfer is more likely among those who are most disadvantaged as measured by Pell status. Table 4 describes the socio-economic composition of four-year community college STEM students.

**Table 4:**
**SES Composition**

| Characteristics | All 4-year STEM | | Four-year Community College STEM Students | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Reverse transfer | | Concurrent enrollment | | Concurrent coursetaking | | Post-graduate coursetaking | |
| | % | Pop. | % | Pop. | % | Pop. | % | Pop. | % | Pop. |
| Pell Grant Recipients | 26% | 107,580 | 33% | 13,512 | 25% | 8,459 | 26% | 19,666 | 18% | 3,908 |
| First generation college student | 38% | 157,232 | 51% | 20,533 | 46% | 15,789 | 52% | 39,861 | 52% | 11,526 |
| Working While Enrolled | 55% | 227,572 | 70% | 28,288 | 56% | 19,189 | 77% | 59,046 | 79% | 17,423 |
| Disabled | 7% | 28,964 | 9% | 3,819 | 9% | 3,169 | 10% | 7,638 | 5% | 1,161 |

*Majors of Four-Year STEM Students Using Community College*

Community college use by field of study shows some notable differences by major. In the science and engineering fields, biology and biomedical students are more likely to pursue

concurrent enrollment rather than reverse transfer whereas in Engineering, Computer Science, and technology fields students are more likely to use a community college for reverse transfer than concurrent enrollments (their major is based on their initial major in the four-year college). Table 5 describes the majors of STEM four-year community college students.

**Table 5:**
**STEM Major in Bachelor's Degree Program**

| | All 4-Year STEM | | Four-year Community College STEM Students | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Reverse transfer | | Concurrent enrollment | | Concurrent coursetaking | | Post-graduate coursetaking | |
| | % | Pop. | % | Pop. | % | Pop. | % | Pop. | % | Pop. |
| *Science & Engineering Fields* | | | | | | | | | | |
| Biological and Biomedical Sciences | 31% | 128,548 | 25% | 10,055 | 36% | 12,342 | 25% | 19,340 | 23% | 4,957 |
| Engineering | 25% | 104,486 | 26% | 10,444 | 21% | 7,354 | 15% | 11,669 | 15% | 3,222 |
| Physical Sciences | 9% | 36,722 | 8% | 3,248 | 10% | 3,529 | 16% | 12,013 | 22% | 4,778 |
| Mathematics and Statistics | 2% | 23,703 | 2% | 772 | 5% | 1,588 | 5% | 3851.7 | 5% | 1,122 |
| Total Science and Engineering | 67% | 293,459 | 60% | 24,519 | 72% | 24,813 | 61% | 46,874 | 64% | 14,079 |
| | | | | | | | | | | |
| *Technician/Technology Fields* | | | | | | | | | | |
| Engineering Technologies | 5% | 19,887 | 8% | 3,196 | 6% | 2,016 | 6% | 4,774 | 5% | 1,037 |
| Computer and Information Sciences | 18% | 76,020 | 26% | 10,628 | 14% | 4,914 | 21% | 15,876 | 13% | 2,878 |
| Agriculture | 6% | 24,403 | 5% | 2,224 | 8% | 2,590 | 12% | 9,480 | 18% | 4,017 |
| Total Technician/Tech. | 29% | 120,310 | 40% | 16,048 | 28% | 9,519 | 39% | 30,130 | 36% | 7,932 |
| | | | | | | | | | | |
| **TOTAL** | 100% | 413,769 | 100% | 81,134 | 100% | 68,663 | 100% | 77,004 | 100% | 22,011 |

*Pathways of Four-Year STEM Students Using Community College*

Finally, we wish to examine the pathways of those entering STEM in their freshman year as compared to those who enter later: How do late STEM entrants differ from initial STEM entrants in terms of community college use and STEM and college persistence? More students who reverse transfer to a community college were freshman entrants than the concurrent enrollee population; that is, late STEM entrants are less likely to reverse transfer, but the differences are small. Compared to the 62% of all STEM students entered STEM in their freshman year, 62% of reverse transfer students were freshman/initial STEM entrants as compared to 56% and 54%

(respectively) of concurrent enrollees and coursetakers. Table 6 describes the pathways of four-year community college STEM students.

The six-year outcomes for reverse transfer students are quite different from that of concurrent enrollees. Whereas 48% of all STEM-ever students in four-year colleges complete a STEM degree within six years or are still enrolled, only 26% of reverse transfers complete continue in a STEM pathway (completion of certificate or degree, or still enrolled) whereas 48% and 49% of concurrent enrollees and coursetakers (respectively) remained in a STEM pathway (completion or still enrolled). Reverse transfers are much more likely to drop out than concurrent enrollees or coursetakers (38% vs. 10% and 20%, respectively).

**Table 6:**
**Pathways**

| | All 4-Year STEM | | Four-year Community College STEM Students | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Reverse transfer | | Concurrent enrollment | | Concurrent coursetaking | | Post-graduate coursetaking | |
| | % | Pop. | % | Pop. | % | Pop. | % | Pop. | % | Pop. |
| *Timing of entry into STEM* | | | | | | | | | | |
| Enter STEM upon initial enrollment | 62% | 257,919 | 62% | 25,326 | 56% | 19,184 | 54% | 41,215 | 47% | 10,416 |
| Switch into STEM after first year of enrollment | 38% | 155,850 | 38% | 15,241 | 44% | 15,148 | 46% | 35,789 | 53% | 11,595 |
| *Retention in STEM Six Years After Enrollment* | | | | | | | | | | |
| In STEM - attained credential or still enrolled | 48% | 199,524 | 26% | 10,409 | 48% | 16,412 | 49% | 37,594 | 62% | 13,753 |
| In non-STEM - attained credential or still enrolled | 28% | 115,784 | 36% | 14,543 | 33% | 11,187 | 41% | 31,853 | 38% | 8,258 |
| Dropped out w/o credential | 24% | 98,462 | 38% | 15,615 | 20% | 6,732 | 10% | 7,557 | NA | NA |

## Discussion

Exploring the STEM and community college pathways of four-year college entrants identifies a number of striking differences in outcomes between those who reverse transfer to a community college and those who have only concurrent enrollment. Students who reverse transfer to a community college from a four-year college are less likely to persist in either a STEM pathway (to a STEM credential or continuing in STEM education) or in college at all, dropping out at about twice the rate as students who use have concurrent enrollment in four year and community

colleges. The major determinants appear to be SES related factors such as income and being the first generation to attend college. When looking at community college use and outcomes by major, engineering majors have much higher rates of reverse transfer and non-completion.

The STEM entry patterns provide some insight into the different pathways for students using community colleges for reverse transfer as compared to concurrent enrollees. Reverse transfer students are more likely to have entered a STEM pathway in freshman year and more likely to drop out without completion in either a four-year or two-year college, at nearly twice the rate of those who are concurrent enrollees. It suggests that their initial entry into STEM fields (and into engineering and computer science in particular) is either more likely to occur among those without adequate preparation, performance levels, and/or "fit" with their major.

Although we do not have the analysis to explore in depth the factors that might account for that difference, we do note some other analyses that provide some relevant background. Studies by the ACT show that, overall, engineering students are less certain about their major than most other students, and engineering and computer science majors have a lower percentage than other STEM majors that ACT finds a good "fit" with interests of those who persist in those majors (ACT, 2014a, 2014b). One inference is that these engineering students face greater challenges than those in other fields in a four-year college, ranging from a harder curriculum to less preparation to lower levels of interest/fit with the major. Perhaps a reverse transfer to a community college represents an alterantive pathway to post-secondary completion in the face of these challenges, though it also appears to be a waypoint toward dropping out altogether. At the same time, community college reverse transfer provides an opportunity to pursue technician programs that four-year colleges may not offer and may be of greater interest and career relevance to students. These data are suggestive and indicate areas for further, in-depth analysis

Furthermore, it could also be that these engineering and computer science fields that provide the greatest academic challenges and thus result in higher drop-out rates, but we might expect to see these students persist after reverse transferring to a community college or another field where academic demands are not as high. At the same time, these students are working more than concurrent enrollees, more likely to be first generation college students and lower SES. Again, this is an area for further research to test these hypotheses as to which are the more determinant factors of reverse transfer and of dropping out.

## Conclusion

This analysis represents a first examination of the ways in which four-year STEM students use community colleges. The analysis suggests a number of interesting and important factors that merit more in-depth study, such as the differential rates of community college utilization by engineering and computer science majors, and the seemingly divergent pathways of concurrent

enrollment and reverse transfer. Some of the striking findings are that early STEM entrants and engineering and computer science majors are much more likely to reverse transfer and to drop out (the other determinants of this pathway are lower income/SES, as might be expected). These findings suggest community colleges could identify these students who are at higher risk of dropping out to provide support services. It may be that these are the students who are not well-suited for these majors, because of interests and/or abilities, and counseling them to find better matches with majors might help them persist to completion. That is, an initial "bad match" could be discouraging them from finding a college major that is a better fit to their interests and/or abilities. Alternatively, it could be that a higher proportion of students in these majors have lower levels of preparation or skills needed for college success. Our inference is that entry into engineering schools in particular would screen out the most poorly prepared and suggests it is an initial bad fit that creates greater hurdles for these students, ranging from early failures (if they are unable to master the demanding engineering curriculum) to disinterest in the particular major being generalized to college more broadly, particularly in fields such as engineering that may limit broader coursetaking and "discovery." These explanations are, of course, speculative and would require more in-depth analysis to explore more fully.

In summary, this analysis provides a lens that broadens the focus of research on community colleges. The role of community college terminal degrees and certificates as providing entry paths to technology jobs is widely discussed, as is the transfer function to four-year degrees. Less attention has been focused on community colleges as an important educational and training pathway into the STEM workforce, either directly or by entry into a four-year college. Generally overlooked has been the dual role of community colleges for four-year students as a supplement or complement to their four-year degree (for concurrent enrollment/coursetaking and/or post-grad courses or certificates) or, for others, as an exit pathway through reverse transfer that can lead to an alternative education and workforce entry route through a two-year degree or certificate; however, the reverse transfer route also appears to be a way station for some four-year students as they stop out of post-secondary education altogether. The two-year, reverse transfer alternative pathway for four-year students may be a positive option for those who find four-year schools a bad fit for their educational and/or career interests, are ill-prepared for a four-year degree, or otherwise seeking an alternative post-secondary option. Unfortunately, it also appears to be a post-secondary exit route that mirrors the race and class disadvantages in the overall education system. Understanding these different functions of two-year colleges for four-year students could enable colleges to address problems leading to drop out for some and, for others, facilitate the complementary role of two-year colleges.

## Addendum

NOTE: Findings on concurrent coursetaking and post-graduate coursetaking have been updated as of June 9, 2016.

**Table 1:**
**Community College Attendance as a Percentage of Four-Year STEM Students**

| Reverse transfer | | Concurrent enrollment | | Concurrent coursetaking | | Post-graduate coursetaking | |
|---|---|---|---|---|---|---|---|
| % | Population | % | Population | % | Population | % | Population |
| 9.8 | 40,549 | 8.3 | 34,343 | 22.9% | 94,604 | 10.9% | 42,534 |

**Table 2:**
**Racial/Ethnic Composition**

| | All 4-year STEM* | | Four-Year Community College STEM Students | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Reverse transfer | | Concurrent enrollment | | Concurrent coursetaking | | Post-graduate coursetaking | |
| | % | Pop. | % | Pop. | % | Pop. | % | Pop. | % | Pop. |
| White | 67% | 277,225 | 58% | 23,383 | 62% | 21,193 | 61% | 57,784 | 64% | 27,243 |
| Black/ African-American | 9% | 38,480 | 16% | 6,371 | 7% | 2,251 | 10% | 9,508 | 5% | 2,148 |
| Hispanic/Latino | 9% | 38,894 | 11% | 4,445 | 14% | 4,694 | 10% | 9,697 | 8% | 3,322 |
| Asian | 9% | 38,482 | 11% | 4,368 | 10% | 3,472 | 11% | 10,397 | 15% | 6,589 |
| All Other | 5% | 20,688 | 5% | 2,000 | 8% | 2,722 | 8% | 7,218 | 8% | 3,228 |

**Table 3:**
**Gender Composition**

| | All 4-year STEM | | STEM Four-year Community College Students | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Reverse transfer | | Concurrent enrollment | | Concurrent coursetaking | | Post-graduate coursetaking | |
| | % | Pop. | % | Pop. | % | Pop. | % | Pop. | % | Pop. |
| Female | 37% | 153,093 | 26% | 10,348 | 38% | 12,882 | 36% | 33,830 | 47% | 20,072 |
| Male | 63% | 260,675 | 75% | 30,219 | 63% | 21,450 | 64% | 60,774 | 53% | 22,462 |
| **Total** | 100% | 413,769 | 100% | 40,567 | 100% | 34,332 | 100% | 94,604 | 100% | 42,534 |

| Table 4: SES Composition | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Characteristics | All 4-year STEM | | Four-year Community College STEM Students | | | | | | | |
| | | | Reverse transfer | | Concurrent enrollment | | Concurrent coursetaking | | Post-graduate coursetaking | |
| | % | Pop. | % | Pop. | % | Pop. | % | Pop. | % | Pop. |
| Pell Grant Recipients | 26% | 107,580 | 33% | 13,512 | 25% | 8,459 | 26% | 24,427 | 27% | 11,327 |
| First generation college student | 38% | 157,232 | 51% | 20,533 | 46% | 15,789 | 39% | 37,160 | 39% | 16,452 |
| Working While Enrolled | 55% | 227,572 | 70% | 28,288 | 56% | 19,189 | 58% | 55,296 | 54% | 23,985 |
| Disabled | 7% | 28,964 | 9% | 3,819 | 9% | 3,169 | 9% | 8,533 | 6% | 2,501 |

| Table 5: STEM Major in Bachelor's Degree Program | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | All 4-Year STEM | | Four-year Community College STEM Students | | | | | | | |
| | | | Reverse transfer | | Concurrent enrollment | | Concurrent coursetaking | | Post-graduate coursetaking | |
| | % | Pop. | % | Pop. | % | Pop. | % | Pop. | % | Pop. |
| *Science & Engineering Fields* | | | | | | | | | | |
| Biological and Biomedical Sciences | 31% | 128,548 | 25% | 10,055 | 36% | 12,342 | 30% | 28,022 | 38% | 16,176 |
| Engineering | 25% | 104,486 | 26% | 10,444 | 21% | 7,354 | 25% | 24,086 | 24% | 10,310 |
| Physical Sciences | 9% | 36,722 | 8% | 3,248 | 10% | 3,529 | 9% | 8,268 | 10% | 4,185 |
| Mathematics and Statistics | 2% | 23,703 | 2% | 772 | 5% | 1,588 | 6% | 5,828 | 7% | 2,888 |
| Total Science and Engineering | 67% | 293,459 | 60% | 24,519 | 72% | 24,813 | 70% | 66,204 | 79% | 33,559 |
| *Technician/Technology Fields* | | | | | | | | | | |
| Engineering Technologies | 5% | 19,887 | 8% | 3,196 | 6% | 2,016 | 5% | 5,090 | 3% | 1,157 |
| Computer and Information Sciences | 18% | 76,020 | 26% | 10,628 | 14% | 4,914 | 17% | 15,648 | 10% | 4,334 |
| Agriculture | 6% | 24,403 | 5% | 2,224 | 8% | 2,590 | 8% | 7,057 | 7% | 3,037 |
| Total Technician/Tech | 29% | 120,310 | 40% | 16,048 | 28% | 9,519 | 30% | 30,130 | 21% | 8,528 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 100% | 413,769 | 100% | 81,134 | 100% | 68,663 | 100% | 94,604 | 100% | 42,534 |

**Table 6:**
**Pathways**

| | All 4-Year STEM | | Four-year Community College STEM Students | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Reverse transfer | | Concurrent enrollment | | Concurrent coursetaking | | Post-graduate coursetaking | |
| | % | Pop. | % | Pop. | % | Pop. | % | Pop. | % | Pop. |
| *Timing of entry into STEM* | | | | | | | | | | |
| Enter STEM upon initial enrollment | 62% | 257,919 | 62% | 25,326 | 56% | 19,184 | 62% | 59,023 | 63% | 26,805 |
| Switch into STEM after first year of enrollment | 38% | 155,850 | 38% | 15,241 | 44% | 15,148 | 38% | 35,581 | 37% | 15,729 |
| *Retention in STEM Six Years After Enrollment* | | | | | | | | | | |
| In STEM - attained credential or still enrolled | 48% | 199,524 | 26% | 10,409 | 48% | 16,412 | 46% | 43,745 | 66% | 28,217 |
| In non-STEM - attained credential or still enrolled | 28% | 115,784 | 36% | 14,543 | 33% | 11,187 | 33% | 31,465 | 32% | 13,641 |
| Dropped out w/o credential | 24% | 98,462 | 38% | 15,615 | 20% | 6,732 | 21% | 19,403 | 2% | 676 |

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