Hidden STEM Producers: Community Colleges' Multiple Contributions to STEM Education and Workforce Development

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May 2014

Abstract

Community colleges have been widely heralded by policymakers as playing an important role in STEM education and workforce development. Yet existing research on community college STEM students and their pathways is limited and does not inform current reform efforts. In this paper, we examine a nationally representative sample of STEM students to understand the types of programs they enroll in, their characteristics, and their enrollment patterns and outcomes. Community college STEM students enroll in two distinct kinds of programs: science and engineering programs (S&E) and technician programs. Whereas S&E programs are transfer-oriented programs that lead to S&E occupations that require bachelor's degrees, technician programs are workforce-oriented programs that lead to technician occupations where subbaccalaureate credentials are valuable. Students in these programs differ in many ways from four-year STEM students and are similar to the broader community college population. Despite their commonalities, community college S&E and technician students differ from each other in their characteristics and experiences. Many students in both S&E and technician programs make decisions about their majors later in their college careers and move in and out of STEM programs relatively frequently, although students in technician programs are more likely to drop out than S&E students. Ultimately, six years after enrollment both S&E and technician students have low credential completion rates, but many remain enrolled in a STEM program. The similarity of community college STEM students to the community college population at large makes broader community college reforms relevant to this particular group of students. Four-year STEM reforms, on the other hand, may need to be considered carefully for their applicability to community college STEM students. Furthermore, while they share characteristics and experiences, S&E and technician students are not a uniform group and require reforms that factor in their distinct goals and characteristics.

Introduction

Community colleges play a unique and significant role in STEM education and workforce development. With their open-access mission, affordable tuition, and locations in almost every community, community colleges enroll nearly half of the nation's undergraduate students, including high numbers of low-income and first-generation college students (AACC, 2014). Furthermore, their mission of serving local workforce needs motivates community colleges to offer a wide array of subbaccalaureate programs with immediate relevance to employment. Given these factors, community colleges provide opportunities in STEM to a diverse group of students in a diverse range of program areas.

Increasingly, community colleges are gaining attention for their role in STEM education and workforce development. Politicians such as President Obama have highlighted the importance of STEM education and the significant role that community colleges can play in training graduates with the skills needed for STEM jobs (Obama, 2012). A recent National Research Council report "Community Colleges in the Evolving STEM Landscape" highlighted the important role of community colleges in STEM education as well as the challenges that community college STEM programs face (Olsen & Labov, 2012). Similarly, a recent National Governor's Association report highlighted opportunities and challenges for states in promoting community college contributions to the STEM workforce (Baber, 2011). While community colleges are not new to STEM education—for instance, the National Science Foundation's Advanced Technological Education program has been actively promoting their role for over 20 years—this recent attention raises questions about how community colleges can contribute moving forward.

Existing research provides a limited understanding of community college STEM students. Much of the research on STEM education is focused on students in four-year colleges and universities and their attrition from STEM fields (e.g., Seymour & Hewitt, 1997; Preston, 2004); these studies do not address the community college context with its distinct mix of students and programs. Major national reports on STEM education provide information on both four-year and two-year students but do not examine issues specific to the community college context (e.g., Chen, 2009, Chen, 2013). Given the differences between the two types of STEM student populations, the extent to which research on four-year STEM students applies to community college STEM students is unknown.

Research on community college STEM is frequently narrow in scope and limited to specific sub-populations, programs, and programmatic issues. Many studies examine the unique role of community college in broadening participation among female and minority populations (i.e., Reyes, 2011; Sorobin & Laanan, 2008; Jackson & Laanan, 2011; Malcolm 2011). Research on community college STEM students has focused on specific types of STEM programs such as manufacturing (e.g. Wang, Chan, Phelps, & Washbon, 2012). Other studies provide valuable contributions to understanding the policies and practices related to implementing community college STEM programs, but do not include data on students (Hull, 2011; Reid & Morest, 2006; Mattis & Sislin, 2005). To date, research has not yet provided the broad view of community college STEM students used in this paper to understand who they are, the programs in which they enroll, how they move through these programs, and the outcomes they attain.

In this paper, we provide a broad national description of community college STEM education and workforce preparation in credit programs. We focus on students in order to understand who they are and determine how they pursue community college STEM education. In so doing, we address the following questions: (1) what STEM programs do community college students enroll in and what are the characteristics of these students? and (2) what are the pathways and outcomes of community college STEM students? In the next section we discuss the method we used to examine these questions. In subsequent sections we report on the STEM programs that students enroll in, the characteristics of students enrolled in these programs, students' enrollment patterns, their entry into and exit from STEM, and their ultimate educational outcomes. We conclude with a discussion about future research and implications for practice.

Method

To conduct this analysis, we use the National Center for Education Statistics' (NCES) Beginning Postsecondary Students (BPS) 2004/09 survey. The survey includes a nationally representative cohort of students enrolled in postsecondary education for the first time in 2003–4 in credit bearing programs.[1,2] Students were surveyed once at the end of their first academic year in 2003–4, a second time in 2005–6, and a final time in 2008–9, 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. The BPS 04/09 dataset includes a total of 16,684 students. In addition to student interviews, the BPS includes transcript data from all institutions that each student attended from the 2003–4 to 2008–9 academic year. We focus this analysis on students who were initially enrolled in a community college in the 2003–4 academic year—a total of 5,489 students. For comparison, when appropriate, we analyze students who initially enrolled in a four-year public or private non-for-profit institutions—a total of 8,327 students. While students who initially enrolled at a four-year college may have later enrolled at a community college, we do not exclusively focus on those students in this analysis. Although such students comprise a sizable population—according to Tsongas (2004), 44 percent of four-year science and engineering graduates attended a community college at some point—they are distinct and better examined in a separate analysis.[3]

In defining STEM, we include the programs most commonly taken as such: biology, math, engineering, physical sciences, computer and information systems, engineering technicians, science technologies and technicians, and agriculture. These programs are typically included in definitions of STEM in prior NCES studies using these data (Chen, 2013; Chen, 2009). We also separately present selected information on social sciences and health professions and related programs in our examination; social sciences are included in some definitions of STEM, and programs in the health professions have high concentrations of science-based courses and are

[1] As with the majority of data sources in postsecondary education, the BPS does not include students who enroll in non-credit programs. While the intensity and outcomes of non-credit programs vary widely, non-credit programs may play an important role in STEM education (Hagedorn & Purnamasari, 2012). Many community college information technology programs, for example, were offered interchangeably between non-credit and for-credit formats (Haimson & Van Noy, 2003).

[2] The BPS does not provide information on STEM students who have had some prior postsecondary experience. Therefore, this sample may understate the issues of older and returning students.

[3] Another related paper examines this population in more depth (Salzman & Van Noy, forthcoming).

typically high enrollment programs at community colleges. While these programs are sometimes defined as STEM programs, they are not consistently included in the definition of STEM in the literature. Therefore, we provide some background information on these programs but focus the analysis on the programs most commonly defined as STEM. We organize the programs that are commonly defined as STEM into two main categories, as further discussed below.

We identify whether a student is in a STEM program using two BPS data items: 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 BPS interviews, 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.

We use BPS data to generate descriptive statistics on program enrollments, student characteristics, entry to and retention in STEM, and educational outcomes in STEM. We generate frequencies and means on key variables in the BPS data for our sample of community college STEM students. We examine the student characteristics and enrollment patterns of four-year STEM students in order to compare them with community college STEM students. We examine student characteristics and enrollment patterns among community college non-STEM students as another comparison group. We then focus exclusively on community college STEM students to examine their entry to and retention in STEM and their educational outcomes in STEM. All statistics were run using appropriate BPS weight variables, as the BPS has a complex sample design (Wine, Janson & Wheeless, 2011). Standard errors were calculated for all point estimates to examine differences across populations and are included in the Appendix.

STEM Enrollments

Community colleges offer numerous STEM programs that prepare students for various occupational goals. These programs fall into two main categories: science and engineering (S&E) programs and technician programs. The former programs prepare students for S&E occupations that typically require a bachelor's degree or more for entry. Through these programs, community colleges provide the opportunity for students to complete the first two years of college, attain an associate degree in arts or science (AA or AS), and then transfer to a four-year institution (Dowd, 2012; Boggs, 2010). These programs include biology, engineering, physical sciences, and mathematics. Technician programs, on the other hand, prepare students for occupations that typically can be entered with a subbaccalaureate credential—such as, an associate degree in applied science (AAS) or other credentials including certificates. These programs include engineering technologies, computer and information sciences, science technologies, and agriculture. These programs have an important role in workforce development, since nearly one quarter of the STEM workforce is composed of workers with a subbaccalaureate education (Langdon, McKittrick, Khan& Doms, 2011). Technician programs generally lead to certificates or associate degrees and provide work-relevant knowledge and skills. Students who begin in technician programs may also continue on to attain a bachelor's degree, as many such programs do have articulated pathways to four-year degrees and some technician jobs do prioritize bachelor's degree holders (Makela, Rudd, Bennett, & Bragg, 2012; Zinzer & Hansen, 2006). Nationally community colleges have a long history of providing technician education in a range of fields, some of which are not offered by four-year institutions (Hull, 2011).

Community colleges have a significant role in STEM education, as reflected in their enrollments. Sizable numbers of first-time community college students enroll in STEM and closely related programs, based on estimates of enrollments from the BPS (see Table 1). At some point in the subsequent six years after their community college enrollment in 2003-4, over 85,000 students enrolled in community college science and engineering programs, and over 250,000 such students enrolled in technician programs. Nearly 373,000 students ever enrolled in health professions and related programs, and over 175,000 students ever enrolled in social sciences.

Table 1: Community College Enrollments by Program, Ever Enrolled in the Six Years After College Entry Among First-time Students Who Began College in 2003-4

	Number of Students	Percent of Students
Science & Engineering Programs		
Biological and Biomedical Sciences	42,152	2.6
Engineering	34,530	2.1
Physical Sciences	23,776	1.4
Mathematics and Statistics	9,134	0.6
Total Science and Engineering	109,592	6.6
Technician Programs		
Engineering Technologies	43,631	2.6
Computer and Information Sciences	101,264	6.1
Science Technologies/Technicians	5,357	0.3
Agriculture	17,577	1.1
Total Technician	167,829	10.2
Closely Related Programs		
Total Health Professions and Related Programs	372,721	22.6
Total Social Sciences	175,397	10.6
Total non-STEM	824,390	50.0
TOTAL	1,649,929	100

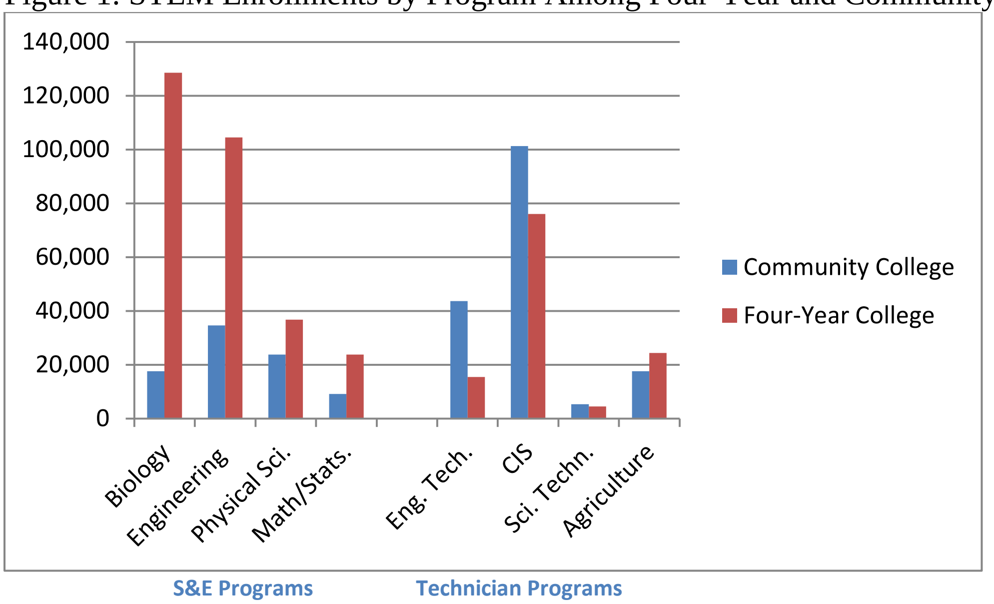
Source: BPS 04/09

Among our sample population, of students who began their studies at a community college, 17 percent reported that they were in a STEM major at some point—that is, they either reported an S&E or technician major in their first year of enrollment or during the six years after enrollment.

An additional 23 percent of community college students reported that at some point they enrolled in a health program, and 11 percent reported that they were, at some point, in a social science program. Taken together, STEM fields and these closely related fields accounted for half of all community college enrollments. These numbers underscore the significant role of community colleges in preparing the STEM workforce and the important contribution of both health and social science programs. While we acknowledge the important role of health and social science programs, we focus the remainder of the paper on core STEM programs and the two types of community college programs they offer: transfer preparation through S&E programs and immediate workforce preparation through technician programs.

Student enrollments and goals across S&E and technician programs reflect their different orientations. S&E programs had notably higher enrollments among four-year students than among community college students (see Figure 1). In particular, biology and engineering programs had very high levels of enrollments among four-year college students compared to community college students. Conversely, most technician programs had higher enrollments among community college students than among four-year college students. Engineering technologies and computer information sciences had high enrollments among community college students compared to four-year college students. These differing enrollment patterns point to the distinct roles that the programs have in occupational preparation. As is the case for enrollments, community college students' credential goals reflect the different program orientations. Among community college technician students, 35 percent reported that their goal was to obtain an associate degree or certificate, compared with only 15 percent of community college S&E students (see Table 2). Similarly, while 60 percent of technician students reported that they ultimately sought a bachelor's degree, 80 percent of S&E students sought bachelor's degrees. While it is possible that some technician programs at community colleges are transfer oriented, such as in computer information science, most likely provide students with skills that can lead to immediate employment while they pursue further education.

Figure 1: STEM Enrollments by Program Among Four-Year and Community College Students



Source: BPS 04/09

Table 2: Community College Student Credential Goals, By Program

	All STEM	S&E	Technician	Non-STEM
Credential Goal (%)				
Bachelor's	68	81	60	62
Associate or Certificate	28	15	35	33
None	5	4	5	5

Source: BPS 04/09

Student Characteristics

Community college STEM students—both S&E and technician—share several key characteristics that make them markedly distinct from the four-year STEM student population. Community college STEM students were older and more likely to be first-generation college students than were the four-year STEM students (see Table 3). While nearly all four-year students were in the traditional college age range of 18–22 upon enrollment in college, less than three quarters of the first-time community college students were in this age range upon enrollment.[4] A markedly higher proportion of community college STEM students were first-generation college students than were four-year STEM students (68 percent versus 38 percent). In addition, community college STEM students were more likely to be working while enrolled than were four-year students (76 percent versus 55 percent), and of those students who did work, community college STEM students were more likely to work more hours (30 hours per week versus 19 hours). Another major challenge facing community college STEM students is the high proportion who were underprepared and required developmental education compared to four-year STEM students (69 percent versus 31 percent).

Community college STEM programs—both S&E and technician—share many of the same fundamental challenges that community colleges face more broadly. On average, community college STEM students are similar to community college students at large on each of the following attributes: age, first generation college student status, work status while enrolled, and developmental education requirements. A large body of existing research on community college students exists on the challenges associated with each of these characteristics, and potential strategies for addressing these challenges. Apart from these characteristics, the major difference between community college STEM students and community college students at large is the low proportion of women enrolled in community college STEM programs (30 percent versus 62 percent).

Though they had many characteristics in common, community college S&E and technician students were distinct from each other in important ways that related to the challenges they faced. Overall S&E students were somewhat more similar to four-year STEM students, while technician students were somewhat more similar to the community college non-STEM population. While both S&E and technician students were older than were four-year students, S&E programs tended to enroll more young, traditional college-age students than did the technician programs; 83 percent of S&E students were between 18 and 22 compared with 66

[4] The BPS only includes first-time students; returning students with prior college education are not included. Thus, the BPS may include a relatively younger student population than actually represented in community college STEM programs.

percent of technician students. Furthermore, while both S&E and technician programs provide access for first-generation college students, technician programs enrolled a greater proportion of first-generation students than did S&E programs (72 percent versus 62 percent). S&E students are also less likely to take developmental education than were technician students (64 percent versus 72 percent).

S&E and technician students also differed in their enrollment by race/ethnicity and gender. S&E programs enrolled relatively high proportions of Latinos, Asians, and female students and a lower proportion of African American students. Latinos comprised a larger proportion of enrollments at community colleges, particularly within S&E programs, than they did at four-year colleges (14 percent in community college STEM overall and 15 percent in community college S&E programs versus 9 percent in four-year STEM programs). Latinos were also enrolled at community college non-STEM programs at higher rates than they were at four-year colleges (16 percent versus 10 percent), so their enrollment in STEM was consistent with their community college enrollment in programs generally. Asian students constituted a greater proportion of community college STEM enrollments in S&E programs (11 percent) than they did in technician (4 percent) or non-STEM programs (4 percent). On the other hand, African American students at community colleges comprised a lower proportion of S&E programs (8 percent) than the technician programs (13 percent) and non-STEM programs (15 percent). Technician programs disproportionately enrolled students who were White and male. White students enrolled at higher rates in technician programs (68 percent) than S&E (61 percent) and non-STEM programs (60 percent). Women enrolled at lower rates in technician programs (24 percent) relative to S&E (40 percent) and non-STEM programs (62 percent).

Table 3: STEM Student Characteristics

	Community College Students				Four-Year Students	
Student characteristics	All STEM	S&E	Technician	Non-STEM	STEM	Non-STEM
Race/ethnicity (%)						
White	65	61	68	60	67	71
Black or African American	11	8	13	15	9	10
Hispanic/Latino	14	15	12	16	9	10
Asian	6	11	4	4	9	5
All other	4	5	4	5	5	5
Female (%)	30	40	24	62	37	62
Pell Grant recipients (%)	26	24	27	29	26	28
First generation college student (%)	68	62	72	73	38	46
Disabled (%)	12	10	14	11	7	8
Age (%)						
18-22	72	83	66	65	95	92

22–40	23	16	27	26	4	6
40+	5	1	8	8	0	2
Average age upon enrollment	22	20	23	24	19	20
Dependent children (%)	17	12	19	26	2	5
Veteran (%)	4	1	6	3	1	0
Working while enrolled (%)	76	78	74	78	55	62
Average hours worked (among those working	30	28	30	30	19	21
Developmental education in first year (%)						
Any	69	64	72	68	31	39
Math	59	56	61	59	23	31
English	14	13	15	18	6	8
Reading	15	15	16	19	4	6

Source: BPS 04/09

Community college students financially benefit from much lower costs of attending community college relative to four-year institutions (see Table 4). The average price of attendance in the first year among community college STEM students was $6,896 versus $18,885 among four-year STEM students. Four-year STEM students have somewhat greater family resources—their expected family contribution is $13,987 versus $9,748 among community college STEM students. However, four-year STEM students are also more likely to take out a student loan while in college compared to community college STEM students (62 percent versus 47 percent), and to take out higher amounts of student loans ($21,143 on average among four-year STEM students versus $15,245 on average among community college STEM students).

Table 4: STEM Students' Financial Characteristics

	Community College Students				Four-Year Students	
Financial characteristics	All STEM	S&E	Technician	Non-STEM	STEM	Non-STEM
Price of attendance in first year	6,896	6,807	7,219	6,601	18,885	17,957
Expected family contribution	9,748	10,079	9,105	8,241	13,987	13,045
Percent with student loans, 6 years later	47	45	52	40	62	64
Average student loan among those with loans, 6 years later	15,245	14,163	17,007	13,438	21,143	21,042

Source: BPS 04/09

Enrollment Patterns

Given the variety of STEM programs and the distinct characteristics of students who enroll in them, we next examined students' enrollment patterns across these programs. Enrollment patterns include: intensity of enrollment (full-time and part-time), continuous enrollment versus breaks across terms, and enrollment at multiple institutions. Students' enrollment patterns are important because of their established relationship with educational outcomes. Community college students' enrollment continuity is positively associated with completion rates, and enrollment intensity is positively associated with transfer rates (Crosta, 2014). Community college students' movement between multiple institutions, a pattern sometimes termed *swirling*, is associated with lower completion rates (Goldrick-Rab, 2006).

Full-time continuous enrollment was not the norm among community college STEM students as it was among four-year STEM students. Only one third of both S&E and technician students attended college full-time for the duration of their enrollment compared with two-thirds of four-year STEM students (see Table 5). In addition, over half of community college STEM students—both S&E and technician—had at least one break of four months or more (that is, longer than a summer) in their enrollment; less than one-third of four-year STEM students have a similar break in enrollment. Interestingly the proportion of students swirling among multiple institutions (more than the two involved in a traditional transfer) is similar across groups—about one quarter of community college STEM, four-year STEM students, as well as community college non-STEM students attend multiple institutions in the six year period after their initial college enrollment. Given what is known about community college students at large, these unstable enrollment patterns have major implications for how students progress along STEM pathways, their time to completion, and ultimate ability to complete, given that articulation between diverse institutions may not always work well.

Table 5: Enrollment Patterns Among Community College STEM Students, By Sub-Field

	Community College Students				Four-year Students	
	All STEM	S&E	Techni-cian	Non-STEM	STEM	Non-STEM
Average enrollment intensity (%)						
Always full-time	33	36	32	27	68	65
Always part-time	13	8	15	22	1	2
Mixed part-time & full time	53	55	53	51	31	33
Constancy of attendance/number of stop-outs (%)						
0	47	49	46	50	71	72
1	41	43	39	35	22	21
2+	12	8	15	15	7	7
Institutional attendance (%)						
Attend only one institution	49	33	59	62	75	74
Traditional transfer	25	41	16	19	NA	NA
Attend multiple institutions, swirling	26	26	25	19	25	26

Source: BPS 04/09

While the enrollment patterns of S&E and technician students were similar, some differences among these groups highlight the specific characteristics and goals of their students. Technician students were more likely to attend part-time exclusively than were S&E students (15 percent versus 8 percent) and were more likely to have multiple stop-outs (15 percent versus 8 percent). These more unstable enrollment patterns likely reflect the somewhat more nontraditional population of older students in the technician program. In keeping with their goal of attaining a subbacacularate credential, technician students were more likely to concentrate their attendance at only one institution—the community college—than were the S&E students (59 percent versus 33 percent). On the other hand, S&E students were more likely to follow a traditional transfer pathway than the technician students—that is, they initially enrolled at the community college and then transferred to a four-year college (41 percent versus 16 percent). The differences in enrollment patterns between S&E and technician students reflect their differences in characteristics and goals.

STEM Entry and Exit

Whether community college students enroll and remain enrolled in STEM majors is a significant concern, especially in the context of students' sporadic enrollment patterns. Prior research has extensively examined students' movement out of STEM programs, particularly among four-year students. Numerous previous studies on four-year students have highlighted in depth the problems and challenges within STEM education that lead students to leave STEM majors (Seymour & Hewitt, 1997; Preston, 2004). Recent research, however, has begun to put STEM attrition in context with attrition in other programs; comparing STEM students with their non-STEM counterparts has documented that movement between majors among these two student groups is similar among both two-year and four-year students (Chen & Soldner, 2013). These findings suggest that switching majors is part of a process of discovery in selecting a major (Mervis, 2014) and point to the importance of examining those factors that attract students to STEM majors.

Relative to their attrition from STEM, less attention has been focused on the students' entry into STEM, particularly those who enter during college, and on the reasons for their entry. Students' program entry is influenced by community colleges processes and timelines for selecting majors. Community college degree programs are inherently shorter than four-year programs, adding pressure on students to select a major sooner in order to fulfill requirements to complete an associate's degree or certificate. At the same time, community colleges are limited in their counseling and advising capacity for students to help make decisions about their programs (Karp, 2013). Many community college students are unsure of what program they want to pursue initially and do not make a decision until late in their enrollment, potentially delaying their progress toward degree completion (Jenkins & Cho, 2012). Selecting a major is further complicated for students who intend to transfer and are not seeking to attain an associate degree, thus may be less likely to officially select a major and/or may select very general community college majors as preparation for a more specific bachelor's degree.[5]

Many students do not know that they want to pursue a STEM major upon initial enrollment in college. Nearly one half of students in both S&E and technician programs chose to enter STEM late, after their first year of community college enrollment (see Table 6). Community college

[5] In this analysis we identify community college students who select a STEM major while at a community college; more detailed analyses of students' transcripts available in the BPS could yield more information on the specific ways that community college students prepare to transfer in STEM fields, regardless of their declared major.

STEM students are more likely to enter programs late (after their first year of enrollment) than four-year STEM students (49 percent versus 38 percent). Among those students who entered STEM late, close to one-half were initially undeclared or undecided for their major. In addition, many other students chose to switch into a STEM major from a wide range of fields, including business, health, mechanics, homeland security, liberal arts, and education. That students entered STEM later is good news; despite concerns about STEM programs pushing students out, these enrollment patterns show that students are also attracted to STEM programs. Little is known about the reasons why these students chose to enter STEM late, although Chen (2013) begins to shed light on students' movement into and out of STEM. Further examination is needed to understand students' motivations for late entry into STEM and the institutional structures that might delay their entry to STEM and/or lead them to switch their major to STEM.

Table 6: Major Decision Making Among STEM Students

	Community College			Four-year College STEM
	All STEM	S&E	Techni-cian	
Timing of entry into STEM (%)				
Enter STEM upon initial enrollment	51	53	51	62
Switch into STEM after first year of enrollment	49	47	49	38
Switch out of STEM to a non-STEM major	33	39	29	28

Source: BPS 04/09

While community college students often enter STEM after initial enrollment, many also make the opposite decision: to leave STEM. One third of both S&E and technician students switched to non-STEM majors by the end of six years after their enrollment (see Table 6). Community college STEM students switch out of STEM at a higher rate than four-year STEM students (33 percent versus 28 percent). These students switched into a range of non-STEM majors including business, health professions, and education. This can be interpreted in two ways. On the one hand, if students learn that they do not like the STEM program and/or they have found a program that is a better match for their interests and abilities, then their departure from STEM is not a negative outcome but rather part of the natural process of exploration and discovery in college. On the other hand, if students have negative experiences in STEM programs they are otherwise actually a good match for, this would be a major concern. More research on the actual experiences and decision-making processes of community college STEM students is needed to understand the reasons why they enter and exit these programs.

STEM Outcomes

Multiple measures of community college STEM outcomes are necessary. To capture community college students' numerous possible successful outcomes requires not just measures of credential completion but also other measures of transfer, credential attainment at other institutions, continued enrollment, and employment (Rassen, Chaplot, Jenkins, & Johnstone, 2013). Taken alone, completion rates do not provide a full understanding of community college student outcomes. Thus we used a range of measures to provide a more comprehensive view of community college STEM student outcomes.

Whether students stay in STEM is an important measure of success for community college STEM programs. This measure includes whether a student has either completed a STEM credential or is still enrolled in a STEM program. Six years after their initial STEM enrollment, one third of STEM community college students were in STEM (Table 7). S&E and technician students were equally likely to be in a STEM field six years after enrollment. However, the trajectories of those who left STEM were quite different across S&E and technician students. Technician students were more likely to drop out than S&E students (37 percent versus 27 percent), whereas S&E students were more likely to switch to a non-STEM field than technician students (39 percent versus 27 percent). Technician students may drop out at relatively higher rates because of their more unstable enrollment patterns and because of the possibility that some may obtain employment with skills they have already attained from selected STEM courses (Washbon, 2013; Booth & Bahr, 2013).

Table 7: Community College Student Retention in STEM Six Years After Enrollment

Outcome (%)	All STEM	S&E	Technician
In STEM - attained credential or still enrolled	30	33	30
In non-STEM - attained credential or still enrolled	33	39	29
Dropped out without credential	37	27	41

Source: BPS 04/09

While credential completion rates are relatively low for STEM students, many students were still enrolled in STEM by the end of the six-year period (see Table 8). Six years after their initial STEM enrollment, 21 percent of S&E students and 20 percent of technician students had attained any STEM credential. As would be expected given their goals, technician students were more likely to attain an associate degree or certificate than S&E students (13 percent versus 5 percent), and S&E students were more likely to attain a bachelor's degree than technician students (16 percent versus 7 percent). In addition to completion, 19 percent of S&E students and 14 percent of technician students were still enrolled in a STEM program at some institution. S&E students were more likely to still be enrolled at a four-year college six years after enrollment than were technician students (13 percent versus 6 percent). This may indicate that many students pursuing an S&E pathway need more than six years to complete a bachelor's degree. Likewise, technician students with unstable enrollment patterns may also require more time to attain a credential.

Table 8: Outcomes Among Community College STEM Students Six Years After Enrollment

Outcome	All	S&E	Technician
Attained STEM credential within 6 years (%)			
Any credential	19	21	20
Bachelor's	10	16	7
Associate or certificate	9	5	13
Still enrolled in STEM six years after initial enrollment (%)			
At any institution	16	19	14
At community college	7	6	8
At four-year college	8	13	6
Transferred to four-year college in STEM at time in six years (%)	25	37	19

Source: BPS 04/09

Note: Students may be included in more than one category.

To put these outcomes in context, on the whole community college STEM students have better outcomes than other community college students. Over half of the non-STEM community college students (52 percent) dropped out after six years, compared with 37 percent of STEM students. These differences may reflect greater motivation among community college STEM students than non-STEM students as opposed to ability; their ability as reflected in developmental education participation were similar. They may also reflect differences in STEM students' experiences in college that may be associated with better retention in college, albeit not necessarily in STEM.

Conclusions and Recommendations

This examination leads to several general conclusions for community college STEM programs and to some specific conclusions for community college S&E and technician programs. We discuss these conclusions and, in each case, make recommendations for future research and practice.

Community college STEM programs may need to adapt reform approaches from four-year STEM programs to the specific needs of their students. Because of the distinct characteristics of their students, community colleges should consider the specific needs of their student population before adopting four-year STEM approaches. For example, undergraduate research experiences have been identified as an effective way to engage four-year STEM students (Hunter, Laursen & Seymour, 2006). However, implementing this strategy at community colleges is difficult because of the limited availability of research experiences at community colleges, given that community college faculty are less likely to be involved heavily in research, but can be conceived of in ways that are consistent with the goals and resources of the community college (Cejda & Hensel, 2009). When available at community colleges, these experiences may need to be designed in ways that are compatible with working students' schedules which may not allow them to engage in lengthy out of classroom experiences. Other types of applied learning experiences, such as work-based learning (including job shadowing and internships), may prove to be particularly useful and relevant for community college students. These types of experiences serve to engage students in applying their STEM learning but in ways that also serve the typical interests of older students in learning relevant skills for the workforce. As with undergraduate research, these experiences need to be tailored to the schedule constraints of many community college students. Other reform efforts may be applied to the community college setting without challenge for students, such as inquiry-based learning and flipped classrooms, but may still need to consider institutional constraints, such as the high number of adjunct faculty at community colleges.

Community college STEM programs face similar challenges with respect to their student population as does the broader community college, and thus will benefit from overall community college reform efforts. Among these reforms, many consider how community colleges can serve older students, who have greater competing work and family demands on their time, as well as additional life experiences that affect their approach to learning and the supports they need. Some common reforms to better serve adults include making scheduling more flexible or accelerated; academic reforms to promote career pathways and make education relevant to work; assistance transitioning into college; and both social and financial supports to promote completion (Kzsis, Callahan, Davidson, McLeod, Bosworth, Choitz & Hoops, 2007; Van Noy & Heidkamp, 2013). Developmental education reform, particularly in math, is a major priority for community colleges at large (Bailey, 2009), and is of particular relevance to community college STEM students (Bragg, 2012). The high rate of placement into developmental education inhibits students' ability to move through programs of study, particularly in STEM programs, which often rely on both foundational and more advanced math skills (Bailey, Jeong & Cho, 2010). Reform efforts around the county include numerous approaches such as contextualization, modularization, acceleration, and more fundamental shifts in developmental education requirements (e.g. Perin, 2013; Edgecombe, Cormier, Bickerstaff & Barragan, 2013; Jaggars, Hodara & West Stacey, 2013; Bragg, 2012).

Community college STEM students frequently move both into and out of STEM programs, and more research is needed to understand the underlying student decision making processes. Since half of community college STEM students enter into STEM after their first year of enrollment, more needs to be known about the factors involved in their decisions and the ultimate implications for student outcomes. While late decisions can waste time because many STEM programs are highly structured with various requirements, early decisions may not be possible or even desirable if students are unsure about their career paths and need time to discover their interests. These decisions are potentially influenced by institutional policies, such as requirements to enter a program that affect students' decision making process by establishing timelines to declare program entry. Research is needed on why students enter STEM programs at different times, the factors that attract them to STEM majors, and how institutional structures might facilitate or delay their entry into STEM. More needs to be known about how to find the optimal balance between students' making an early decision and making a solid, well-informed decision. Give the often limited resources for counseling and advising at community colleges, strategies to inform student decision making and provide additional support need to be identified.

In addition to the students who switch into STEM, one third of STEM students ultimately leave STEM for a non-STEM major. Recent analyses have found that students are more likely to leave STEM fields if they perform poorly in their STEM classes relative to their non-STEM classes (Chen, 2013). However, the underlying reasons for students' relatively poor performance are not known, such as the role of instructor grading practices in STEM, so it is unclear whether students have found a better match or whether they have left because of negative experiences in their STEM courses. More research is needed in the community college context on the factors related to students' movement out of STEM programs.

Technician programs need to promote focused engagement strategies to address the needs and goals of their students. Technician programs in particular have challenges because of their older, less advantaged student population. These students have greater instability in their enrollments and are more likely to drop out than S&E students. Given these specific challenges, technician programs can support their students most effectively by using strategies that promote their engagement, such as flexible programs to accommodate part-time attendance when it is the only option for students, supports to enable full-time attendance when possible, and outreach to ensure they reengage students after stop-outs. Technician students have more sporadic enrollments concentrated at one community college and may require particular strategies to promote their continued engagement. For instance, enhanced cooperative arrangements between colleges and the current or prospective employers of these workers may promote engagement and retention. Community college technician students face greater challenges with developmental education because so many need to take these courses. Reforms targeted specifically to their workforce goals may be particularly beneficial. These include integrated approaches to improving basic skills while teaching technical skills such as in the I-BEST program model (Wachen, Jenkins & Van Noy, 2011). Furthermore, research is needed on those who do drop out to understand their pathways after leaving the community college and whether any have benefited from their STEM education in their subsequent employment, despite their lack of a credential.

The lengthy persistence of community college STEM students, particularly S&E students, requires community colleges to employ different responses and outcomes measures. While low completion rates among community college STEM students are a major concern, their high persistence rates are notable. They take a long time to finish with a lot of part-time enrollment and interruptions in their enrollment, but many do persist. This persistence raises questions about what programs can do differently to help students finish sooner. Reforms to accelerate learning may help but must be carefully implemented to preserve quality. At the same time, some students may simply require more than six years to complete their STEM education—this is likely to be particularly true of S&E students who typically seek a bachelor's degree. These students may receive the greatest benefit from improvements in transfer and articulation policies that streamline their pathway to a bachelor's degree. In addition to strategies to improve student progression, outcomes need to be judged based on multiple measures, recognizing the long time to completion among many community college students, particularly those on transfer pathways.

Our examination of student pathways and outcomes in credit-bearing STEM programs has uncovered some of the many ways in which community colleges educate the STEM workforce. We have identified some potential barriers to successful outcomes among community college STEM students and have offered suggestions for future research and practice. In addition to the recommendations noted above, further research is needed on other contributions of community colleges to the STEM workforce, including educating four-year STEM students who enroll at community colleges, and providing targeted skills training in non-credit STEM programs. The actual contributions of community colleges in STEM education are numerous and differ from those of four-year colleges; thus, reforms to improve community college STEM programs require an understanding of both the general community college context and the particular goals of each community college program.

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Appendix

Standard Errors for Table 2: Community College Student Credential Goals, By Program

	All STEM	S&E	Technician	Non-STEM
Credential Goal				
Bachelor’s	3.3	3.0	4.3	1.4
Associate or Certificate	3.1	2.7	4.1	1.4
None	1.1	1.4	1.5	0.6

Standard Errors for Table 3: STEM Student Characteristics

Student characteristics	Community College Students				Four-Year Students	
	All STEM	S&E	Techni-cian	Non-STEM	STEM	Non-STEM
Race/ethnicity						
White	2.9	3.6	3.4	1.9	1.9	1.3
Black or African American	1.4	1.6	1.8	1.2	1.6	1.1
Hispanic/Latino	1.9	2.5	2.1	1.1	1.2	0.6
Asian	1.0	2.4	1.0	0.5	0.8	0.4
All other	0.9	1.6	1.0	0.5	0.6	0.5
Female	2.5	4.0	2.3	1.1	1.3	1.0
Pell Grant recipients	2.3	3.0	3.2	1.0	1.4	0.7
First generation college student	2.1	3.4	2.8	1.0	1.4	1.0
Disabled	1.8	2.1	2.7	0.7	0.7	0.5
Age						
<22	2.6	3.1	3.2	1.3	0.8	0.7
22–40	2.9	3.1	3.6	1.1	0.8	0.6
40+	1.3	0.7	2.0	0.7	0.2	0.4
Percent with dependent children	2.3	2.6	3.2	1.1	0.4	0.5
Percent veteran	2.2	0.3	3.4	0.4	0.2	0.1
Percent working while enrolled	1.9	2.5	2.8	1.2	1.5	1.0
Developmental education in first year						
Any	2.3	3.5	2.8	1.6	1.9	1.4
Math	2.5	4.5	3.5	1.7	1.7	1.5
English	1.8	2.9	2.6	1.3	1.5	0.9
Reading	1.9	2.4	2.5	1.3	0.9	0.9

Standard errors for Table 4: STEM Students' Financial Characteristics

Financial characteristics	Community College Students				Four-Year Students	
	All STEM	S&E	Techni-cian	Non-STEM	STEM	Non-STEM
Price of attendance in first year	240.82	314.16	327.58	124.64	305.36	198.34
Expected family contribution	1,581.03	2,162.73	1,046.54	303.47	484.66	274.66
Percent with student loans, 6 years later	2.5	3.5	4.2	1.0	1.4	0.8
Average student loan amount among those with loan, 6 years later	833.17	1,115.85	1,105.60	523.14	554.54	342.92

Standard Errors for Table 5: Enrollment Patterns Among Community College STEM Students, By Sub-Field

	Community College Students				Four-Year Students	
	All STEM	S&E	Techni-cian	Non-STEM	STEM	Non-STEM
Average enrollment intensity						
Always full-time	2.5	5.0	3.7	1.1	1.3	1.0
Always part-time	2.2	2.6	2.8	1.1	0.3	0.3
Mixed part-time & full time	2.5	4.8	2.9	1.1	1.3	1.0
Constancy of attendance/number of stop-outs						
0	3.2	3.1	4.7	1.3	1.3	0.9
1	2.5	3.4	3.2	1.2	1.2	0.8
2+	1.8	2.0	2.6	0.9	0.7	0.5
Institutional attendance						
Attend only one institution	2.4	3.4	3.2	1.3	1.3	0.9
Traditional transfer	1.9	3.0	2.2	0.9	NA	NA
Attend multiple institutions, swirling	2.9	3.5	3.7	1.0	1.3	0.9

Standard Errors for Table 6: Major Decision Making Among STEM Students

	Community College			Four-Year College
Timing of entry into STEM	All STEM	S&E	Technician	STEM
Enter STEM upon initial enrollment	3.5	4.2	3.8	1.5

Switch into STEM after first year of enrollment	3.5	4.2	3.8	1.5
Switch out of STEM to a non-STEM major	2.3	3.9	4.2	1.6

Standard Errors for Table 7: Community College Student Retention in STEM Six Years After Enrollment

Outcome	All STEM	S&E	Technician
In STEM - attained credential or still enrolled	2.6	3.1	4.2
In non-STEM - attained credential or still enrolled	2.3	3.9	2.9
Dropped out without credential	2.7	3.2	4.7

Standard Errors for Table 8: Outcomes Among Community College STEM Students Six Years After

Outcome	All STEM	S&E	Technician
Attained STEM credential within 6 years			
Any credential	2.1	3.0	3.3
Bachelor’s	1.4	2.4	1.5
Associate or certificate	1.7	1.2	2.9
Still enrolled in STEM program six years after initial enrollment			
At any institution	1.7	2.4	2.1
At community college	1.4	1.6	1.8
At four-year college	1.1	2.1	1.3
Transferred to four-year college in STEM at any point in six years	2.0	3.3	2.4