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Classifying STEM Programs in Community Colleges to Develop a State-Level Middle-Skill STEM Workforce Strategy

A CAPSEE Working Paper

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Abstract

Calls to increase the number of undergraduate STEM credential recipients have largely failed to differentiate between sub-baccalaureate and four-year credentials at the undergraduate level, which is problematic for workforce development. In this paper, the authors develop a classification system for sub-baccalaureate STEM credentials that is incorporated into an analysis of administrative data from the Virginia Community College System. The authors first describe sub-baccalaureate STEM students and then examine the relationships between STEM matriculation and short-term outcomes for six cohorts. The authors use Mincerian regressions to estimate the earnings associated with completing a STEM credential four years after initial enrollment. In addition to confirming that students with career-oriented credentials drive short-term STEM earnings benefits, and that full-time students are more likely to complete credentials than their part-time peers, this study also finds relative homogeneity between STEM and non-STEM community college students, suggesting that ability may not be the primary factor inhibiting middle-skill STEM workforce preparation. The authors conclude by discussing the findings and suggesting how these data could be useful in better aligning Virginia's economic development plans and postsecondary educational offerings.

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1. Introduction

Considerable attention has been paid to the labor market returns to postsecondary STEM credentials (Carnevale, Smith, & Melton, 2011; Rothwell, 2013; President's Council of Advisors on Science and Technology, 2012; Van Noy & Trimble, 2010). In addition to the economic benefits to society that result from having more STEM-educated workers, individuals with associate or bachelor's-level credentials in STEM generally have substantially higher earnings than their peers with non-STEM credentials. However, research on the relationship between STEM credentials and labor market outcomes has disproportionately focused on four-year colleges and universities, despite the fact that community colleges enroll nearly half of all postsecondary students (Bailey & Morest, 2006). Further, according to Rothwell (2014), STEM jobs include a variety of blue-collar, craft, and professional occupations, half of which can be satisfied by a community college education. Thus while community colleges represent an important part of the STEM workforce pathway, there is little research on the labor market returns from postsecondary STEM credentials earned at two-year colleges.

Properly identifying the earnings benefits for community college STEM credentials is challenging for multiple reasons. First, while attending and completing a sub-baccalaureate credential results in significant earnings gains (Belfield & Bailey, 2011), this research is not attentive to STEM credentials specifically. Various studies have both estimated returns to completing community college credentials (e.g., Xu & Fletcher, in press; Bahr et al., 2015) and analyzed returns to specific subject fields, but none of these studies have focused on STEM. In fact, there is no consensus on which programs of study constitute STEM in community colleges (Oleson, Hora, & Benbow, 2014), making comparisons of research on the benefits of the various vocational, career and technical education (CTE), and occupational credentials almost impossible. Second, research on community college pathways in STEM tend to focus on baccalaureate outcomes (Wang, 2014), rather than on both sub-baccalaureate credentials oriented toward careers as well as those geared toward further education. Despite sustained discourse on STEM credentials for workforce development and the importance of community colleges (Olson & Labov, 2012, the literature to date provides little insight on what constitutes sub-baccalaureate STEM programs, who sub-baccalaureate STEM students are, and how these students fare in terms of economic outcomes, particularly in the short term.

In this paper, we acknowledge and attempt to address these limitations by taking a close look at the types of STEM programs offered in the Virginia Community College System (VCCS), student course-taking patterns and outcomes, and the short-term earnings returns to credentials. The research questions guiding this work are: What are sub-baccalaureate STEM credentials? Who are sub-baccalaureate STEM students academically and demographically? What are their graduation and transfer outcomes? And, what are the short-term labor market outcomes for sub-baccalaureate STEM students in career- and transfer-oriented programs of study? In answering these questions we outline a classification system for sub-baccalaureate STEM credentials. Using descriptive and Mincerian analyses, we consider the relationship

between student characteristics and the labor market returns to sub-baccalaureate credentials for first-time-in-college students who enrolled in the VCCS and declared a STEM major between 2004 and 2009.

Our paper is structured as follows. First, we review the relevant literature and discuss the methodological challenges involved in estimating the returns to college, and to STEM credentials specifically. Second, we describe the datasets used in our analysis and outline a classification for STEM programs at community colleges. After describing the demographic and academic characteristics of STEM compared to non-STEM students, we note the differences in these traits among students within the aforementioned STEM classification system. Finally, we present our findings on the short-term returns to STEM credentials and a series of subgroup analyses and robustness checks. In the final sections, we discuss some of the implications of this research for Virginia and offer suggestions for further investigation.

2. Community Colleges and Middle-Skill STEM Credentials

Postsecondary STEM Pathways

Despite the significant body of work suggesting that *in general* community colleges have a negative effect on students eventually pursuing bachelor's degrees (Dougherty, 1992; Long & Kurlaender, 2009), research, industry, and government stakeholders are increasingly interested in the role of community colleges in postsecondary STEM pathways (Olson & Labov, 2012). These institutions represent an opportunity to expand and diversify the STEM workforce as they disproportionately enroll ethnic/racial minority and low-income students (Berkner & Choy, 2008), populations that are growing significantly and that are underrepresented in STEM fields (Lundy-Wagner et al., 2014).

However, research on postsecondary STEM pathways that include community colleges tends to focus on these institutions solely as a vehicle for eventual bachelor's degree completion. For example, Wang (2014) analyzed the Beginning Postsecondary Students longitudinal study (BPS:04/09) and the Postsecondary Education Transcript Study (PETS:09) to estimate the effect of beginning at a community college on completing a STEM bachelor's degree. As with more general research on two-year institutions, her analysis found that students starting at a community college were less likely to earn a STEM bachelor's degree. However, further analysis suggests that after accounting for credits attempted and accumulated in STEM courses during the first year, the negative effect of community college attendance on STEM bachelor's degree completion could be reduced or eliminated. Although this baccalaureate-focused research sheds light on one possible STEM pathway from community colleges, it effectively ignores the fact that these institutions serve many students seeking shorter-term credentials geared toward work (e.g., Xu & Trimble, 2014).

Clarifying What Constitutes Postsecondary STEM

While some stakeholders are concerned about increasing the STEM skilled workforce, few acknowledge the lack of consensus on what constitutes STEM (Oleson et al., 2014), and how that may affect recruitment and retention in colleges or workforce and economic development strategies. In fact, the positive and significant labor market gains associated with postsecondary STEM credential receipt are often in reference to lifelong earnings for bachelor's degree recipients (e.g., Carnevale, Smith, & Melton, 2011). Given the exponential growth in the number of shorter-term credentials conferred in the past fifteen years (Xu & Trimble, 2014), many community college students appear to be seeking short-term labor market benefits. Therefore, clarifying which community college programs are indeed in STEM fields, which confer early economic benefits, and the strength of the potential benefit can have important implications for development strategies concerning the middle-skill and professional-level STEM workforce.

Extant research on labor market outcomes for community college credentials associated with fields that may be considered STEM is rather consistent, despite the lack of continuity in terms of what constitutes STEM. For example, some research has found that CTE programs confer individuals earning certificates and associate degrees relatively large earnings benefits compared with completers in non-CTE fields (Jespen, Troske & Coomes, 2014; Van Noy & Trimble, 2010). Others mention higher returns to quantitative and technical fields (e.g., Grubb, 1997; Jacobson, LaLonde, & Sullivan, 2005), and in rare cases researchers include the term "STEM" to describe fields that result in higher earnings (e.g., Carnevale, Rose, & Cheah, 2011). Despite those findings, the term "STEM," like "technical," "vocational," or "CTE" is rarely defined in ways that provide clear continuity in the interpretation of research.

Rothwell (2013) notes that the term STEM is ultimately an umbrella term for programs that vary in terms of their math, science, and technology content. Indeed, the common dichotomy of "STEM" versus "non-STEM" masks what may be important differences in student preparation, achievement, and outcomes by program of study (e.g., Carnevale, Smith, & Melton, 2011; Rothwell, 2013). For instance, within two-year institutions, math requirements for entry into and success in a mechanical design program are not necessarily equivalent to those for science programs or a construction management technology program, and yet all may be considered sub-baccalaureate STEM programs.

Further, and as noted earlier, the intended outcomes of STEM credentials vary across two- and four-year institutions. This is reflected in the fact that programs at community colleges and four-year institutions may have similar content but have been developed and are accredited separately. For example, electrical engineering bachelor's degree programs are accredited by the Accreditation Board for Engineering and Technology (ABET), whereas electrical engineering technology programs in two-year colleges are accredited by ABET's Engineering Technology Accreditation Commission. As a result, community college students in career-oriented programs may face considerable challenges in formally and systematically converting relevant knowledge

into credits for a similar bachelor's degree program (using stackable credentials). Thus, while STEM may engender popular rallying cries in education and workforce development, the fact that its meaning is ambiguous makes it difficult to understand differences between STEM and non-STEM students in community colleges as well as STEM students across two- and four-year contexts. What is also overlooked is the significant number of community college STEM students who are not choosing to pursue four-year STEM bachelor's degree programs and how program of study and credential orientation (career or transfer) affect baccalaureate STEM labor market outcomes for students who initially attend a community college.

Labor Market Gains to Community College Credentials

By design, community colleges have a strong and positive economic impact on their local communities and the nation. Research suggests that for each associate degree from a community college, the returns to taxpayers are approximately $142,000 in revenue (Trostel, 2010). Most of the benefit is derived from income tax payments (due to higher earnings of students who earn degrees); however, there are also savings in government-funded programs, namely those associated with crime, health care, and welfare. Belfield and Jenkins (2014) noted that taxpayers invest approximately $54,800 per associate degree on average, resulting in returns nearly three times over. In addition, male and female students who earn an associate degree benefit by 13 and 21 percent, respectively, compared to their same-gender peers with only high school credentials (Belfield & Bailey, 2011). For those community college students that transfer and complete a bachelor's degree, the benefit is larger with precipitous earnings growth after college graduation, which contributes to better long-term returns (Belfield, 2013; Belfield, Liu, & Trimble, 2014). While the evidence on short-term certificates (awards that take less than a year to complete) is mixed, long-term certificates appear to have positive returns for most students (Xu & Trimble, 2014).

Research shows that lifetime earnings increase significantly for workers as their level of educational attainment increases (Carnevale, Rose, & Cheah, 2011; Kane & Rouse, 1999). The size of the return for any credential varies as well: earnings gains are higher for those in fields generally considered more quantitative or career-technical, especially nursing and other health fields, with smaller gains for students completing liberal arts associate degrees (although the latter finding is expected, as most sub-baccalaureate liberal arts students intend to transfer to bachelor's degree programs). In addition, research literature on the returns to community college has used program of study to help explain gender segregation in postsecondary educational access and occupations (see Belfield, Liu, & Trimble, 2014; Gill & Leigh, 2000). For example, Grubb and colleagues (Grubb, 1997; Grubb, Badway, Bell, Bragg, & Russman, 1997) found that the highest earnings benefits to men were for engineering, computer-related, and health-related certificates or associate degrees; for women, the highest returns were for health-related certificates or health and business associate degree programs. In sum, most student pathways from community colleges lead to positive economic returns for students (Belfield & Bailey,

2011; Oreopoulos & Petronijevic, 2013), though there is variability by program of study and gender.

Labor Market Gains to Community College STEM Credentials

As mentioned, extant research on returns to community college credentials has not focused on STEM programs specifically. However, due to the practice of parsing out fields of study and estimating returns to such fields, we are able to glean some, if imperfect, insight on such programs from previous studies. For example, Bahr and colleagues (2015) utilized a fixed effects model to estimate returns to field-specific credentials in Michigan community colleges during the seventh year after initial enrollment. While they found positive returns to associate degrees, they also noted that students who credentialed in nursing and other health-related fields were the primary drivers of the positive returns. For men, the strongest returns came from "technical" fields, such as information sciences and engineering and science technologies. They estimated returns between 13–28 percent for these highest return fields.

Jacobson and Mokher (2009) studied the effects of various degree types on labor earnings for a single cohort of public school students from Florida. Using an unusually rich dataset, they employed OLS regression to control for various aspects of educational preparation and course taking. The findings indicate that students with certificates or associate degrees in health-related professions had earnings[1] 42 percent greater than those with certificates or associate degrees in the humanities. Those from "vocational-technical" programs had earnings 20 percent higher than humanities students. On the other hand, students concentrating in programs classified under a more traditional STEM grouping had earnings only about 13 percent higher than humanities students.

In another example, Xu and Fletcher (in press) used a Mincerian approach to analyze outcomes for students in the Virginia community colleges the ninth year after initial enrollment. In their analysis, most fields considered to be STEM fields showed mixed to weak returns. Completion of certificates and associate degrees in engineering sciences and information sciences showed insignificant, occasionally negative, economic returns. Nursing and allied health graduates had much larger and significant returns. Specifically, female nursing associate degree graduates had $1,876 in quarterly earnings returns, and those from allied health programs had quarterly returns of $793.

The conclusion drawn from the field-specific estimates generated by these studies is that there is a large range of returns for STEM students in the community college context. Part of the reason for such a broad claim is that this research often employs study-specific frameworks to classify STEM (and non-STEM) programs, which often results in inconsistent definitions of STEM. Further, in instances where there is some consensus around classification—via use of

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[1] Jacobson and Mokher (2009) used the highest annualized earnings for each individual during the eighth to twelfth years after ninth grade as the outcome variable.

CIP codes[2]—four-year programs are privileged. For example, CIP code 11 ("Computer and Information Sciences and Applications") includes both computer science and data entry programs, programs that require vastly different skills and that lead to distinct credentials. Therefore research that groups programs of study by CIP codes may unintentionally mask differences between STEM and non-STEM programs.

The major takeaway from recent literature is that, without a consistent framework that is attuned to the nuances of community college STEM programs, the field will remain unable to attain consistency and comparability between study results on this topic. As a result, despite acknowledging the value of community college credentials, we must also realize that the extant literature provides neither a clear understanding nor comparable estimates of sub-baccalaureate STEM credentials. In this paper, we seek to contribute to both. By clarifying how career- and transfer-oriented credentials affect short-term labor market outcomes, we can provide critical information to students at community colleges seeking full-time employment as well as those seeking entrée to a bachelor's degree program. We focus on the short-term labor market outcomes in these fields, which highlights the tension between promises of long-term economic gains for postsecondary STEM credentials and the reality that many community college students seek educational and economic benefits that will improve their short-term economic situation. The analysis is intended to help clarify how community colleges can support and reinforce both middle-skill and professional-level STEM workforce development.

3. Method

The current study investigates two areas of relevance for institution- and state-level policymakers concerned with short- and longer-term STEM workforce development. First, we describe the data and a sub-baccalaureate STEM classification scheme used to organize STEM programs and credentials. Then we document the differences between STEM and non-STEM students in one community college system in terms of demography as well as by completion or transfer status. Finally, we explore the extent to which sub-baccalaureate STEM credentials may increase short-term economic benefits to students.

Data

Our analysis is based on a longitudinal, student-level administrative dataset from the Virginia Community College System (VCCS). During the 2012–2013 academic year, the system included 23 community colleges serving approximately 279,970 students. Many students, however, are clustered within a few larger institutions in the system, such as Northern Virginia

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[2] Classification of Instruction (CIP) codes are the National Center for Education Statistics' (NCES) taxonomic scheme for consistent tracking and reporting of programs and fields of study.

Community College (NOVA) and Tidewater Community College, which together serve over 100,000 students.

The VCCS administrative dataset includes information on student demographics, course transcripts, program major,[3] remedial coursework, financial aid, graduation dates, and credential status. We matched these records to National Student Clearinghouse (NSC) data to determine whether, when, and where students transferred outside of the community college system. We also matched the student record data with Unemployment Insurance (UI) records. The earnings data are reported on a quarterly basis and include the North American Industry Classification System (NAICS) codes for the industry in which the student had earnings. All earnings data are adjusted for inflation and expressed in 2010 dollars. Overall, we had access to student-level data from 10 cohorts of individuals who first enrolled in college between 2004 and 2013. To maximize our sample while allowing for sufficient longitudinal data, we limited the sample to first-time-in-college students who enrolled between 2004 and 2009.

The administrative dataset's strength lies in the extensiveness of its longitudinal student enrollment data, its detailed transcript data, and its thorough inclusion of background and demographic data. The ability to follow various cohorts of students from the same system over time enabled us to study changes during a select time horizon and minimize the effects of the recession—which occurred during the time when many students from our first two to three cohorts who earned a credential were entering the labor force—along with its lingering economic impacts.

The main limitations of the dataset are missing data; a lack of detailed information on students' work experience prior to their first enrollment; and the co-occurrence of our time horizon and the Great Recession of 2007, which is not ideal for estimating labor market returns. We addressed the latter two issues by using age as a proxy for years of experience (similar to Dadgar & Weiss, 2012) and incorporating fixed effects for each quarter. Missing data, however, is a more significant issue, as the dataset contains earnings data only for students working in Virginia, five other proximate states, and the District of Columbia (DC). Data are missing for individuals employed by the federal government, which is nontrivia given that Virginia borders the nation's capital; students who attended NOVA, which is especially close to DC, could be underrepresented in the analysis, thus biasing the estimates.[4] This is especially a concern if NOVA enrolls many students in STEM programs that align with federal jobs. Further, if a significant number of students were employed in a state for which earnings are available in our dataset, and moved to work in a state for which we do not have earnings data, we may underestimate earnings gains. The same could happen if students were to work in multiple states at one time, as the data could reflect

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[3] Program major, although measured in the dataset at each term, is used to identify the student's major at initial enrollment to derive our STEM classification system. In our subsequent estimations of labor market outcomes, we find that there are not significant differences depending on whether students are classified as STEM at initial enrollment or final semester of enrollment.

[4] NOVA enrolls more science and engineering majors, and fewer health science and nursing majors, relative to the rest of the state's community colleges. If a disproportionate amount of these students obtained federal jobs, it could bias our estimates.

earnings from one state but not another. Overall, the missing data could have significant implications for our analyses.[5]

Among the six cohorts included in the study, we followed 140,971 first-time-in-college students, 48,081 (or 34 percent) of whom were enrolled in a STEM program during the first semester.[6] Within three years of entry, 19 percent of our sample obtained at least one credential and 30 percent transferred to another institution; 54 percent were female. The means for the full sample, however, are not representative of every VCCS institution, or even most. Depending on the variable, institutional ranges varied widely. For example, across all students in all VCCS institutions, the proportion of Black students ranged from 1 percent to 46 percent, the proportion of STEM students ranged from 15 percent to 81 percent, and the proportion of students obtaining at least one credential ranged from 15 percent to 41 percent. Additionally, the VCCS includes two institutions with significantly larger student bodies—NOVA and Tidewater Community College. Students from these two institutions make up over 43 percent of students in the sample. This heterogeneity makes it difficult to generalize our findings to any single institution, so findings should be interpreted solely at the state level.

Sub-baccalaureate STEM Classification Scheme

We solicited feedback from the VCCS and other experts on community colleges to develop a classification scheme relevant to policy making for postsecondary STEM credentials. The most significant consideration was the inclusion of allied health programs. While these programs are not always considered part of STEM, especially at four-year institutions, community college leaders argued that allied health programs often require more than basic math or science coursework. Using this information and extant research, we devised a classification of three STEM program categories relevant to community colleges: (1) traditional STEM fields (e.g., engineering or biology); (2) allied health STEM fields (e.g., licensed practical nursing or occupational therapy); and (3) technology and technician STEM fields (e.g., automotive technology or heating, ventilation, and air conditioning [HVAC] technician), which tend to be more vocational in nature but still have requirements in math or science. Traditional STEM majors are the closest to bachelor's-level programs in engineering and science and tend to have a transfer orientation; allied health STEM programs represent mostly vocational and a few transfer-oriented programs.

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[5] We provide more explanation about how we treated missing earnings data below in "Method for Estimating Labor Market Returns" (p. 14).

[6] We sampled students by initially selected major, marking them as STEM students as long as they had a designated major in STEM their first semester. As a test of robustness, we also estimated returns for students with a STEM major in their final semester. Given the rising popularity of and emphasis on STEM, a slightly higher proportion of the students (38 percent) ended up with a STEM major in their final semester. Despite that, we observed no significant differences in estimates between the two sampling methods.

Information on credential types,[7] credential orientations, and STEM program categories was used to classify VCCS programs of study offered between 2004 and 2009. First we identified programs of study that could be considered STEM, and assigned them to one of the three program categories. Then we used the credential type to discern career or transfer orientation. Table 1 presents an overview of the classification system that is used throughout this paper. For a full listing of VCCS STEM majors, their program categories and credential orientations, and the proportion of STEM students enrolled in each, see the appendix.

Table 1 shows that between 2004 and 2009 the VCCS offered six relevant credential types, of which the vast majority are career oriented programs, intended to prepare students for work (not transfer to a four-year bachelor's degree program). There are considerably more allied health and technology and technician STEM programs than programs in traditional STEM fields. In addition, while there are STEM transfer programs, these five programs represent less than 10 percent of all STEM programs offered. The actual proportion of students in the programs, though, differs greatly from the representation of programs. Across the six cohorts, about 17 percent of our sample population initially enrolled in a traditional STEM field, 9 percent in allied health, and 8 percent in technology or technician programs. This means that, of all STEM students, the majority are in traditional STEM programs. Students from transfer programs make up 57 percent of all students, whereas credential program students only make up 43 percent. The dissimilarity between proportions at the program-level and student-level is due to the sizeable student body accepted into transfer-oriented, traditional STEM programs.

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[7] In the VCCS, the following credentials are conferred: Associate of Arts (A.A.), Associate of Arts and Sciences (A.A. & S.), Associate of Applied Arts (A.A.A.), Associate of Applied Science (A.A.S.), Associate of Science (A.S.), Certificate, and Diplomas. For reference, certificates are typically comprised of 30 credit hours, where 15 percent of the coursework is in general education and students must take at least one three-credit-hour English course. Diplomas have a two-year curriculum in a career/technical area with the same requirements as a certificate. See http://courses.vccs.edu/programs.

Table 1: VCCS STEM Offerings by Credential Type, Credential Orientation, and STEM Program Category, 2004–2009

VCCS Credential Types	Credential Orientation		Number of VCCS STEM Programs		
	Career	Transfer	Traditional STEM	Technology/ Technician	Allied Health
Certificate	X		0	11	7
Diploma	X		0	6	0
Associate of Applied Science (AAS)	X		1	30	14
Associate of Arts (AA)		X	0	0	0
Associate of Arts and Sciences (AA&S)		X	2	0	0
Associate of Science (AS)		X	2	1	0
Total	3	3	5	48	21

Note. Some STEM programs may award multiple credentials; in this table each program is included once and is not double counted, even if programs are highly similar. For example, many programs in Technology/Technician are highly similar in terms of subject and curriculum (e.g., Automotive Technology, Automotive Diagnosis, Automotive Analysis & Repair, and Autobody Mechanics), but each is represented as a separate program in this table. Also, while the VCCS offers an associate of applied arts (A.A.A.), that credential is not relevant in this study.

Trends in STEM and Non-STEM Students

The increasing perceived importance of STEM is clearly reflected in the data. According to broad estimates based on initial enrollments, the 2004 through 2009 cohorts exhibited a 50 percent increase over the period in the percentage of students who initially enrolled in a STEM program. This growth was especially strong in the allied health fields, where the student body grew nearly 60 percent over the same period.

Table 2 displays basic descriptive statistics on the STEM and non-STEM students in our sample, who are highly similar in terms of demography. STEM students are slightly more likely to be male, but the two groups have similar ethnic/racial compositions, and students are about the same age. On average, both STEM and non-STEM populations are more than 60 percent White and were between ages 21 and 22 at first enrollment. Although the proportion of students working while enrolled was about the same for STEM and non-STEM students, Pell grant receipt was slightly more common among STEM students (55 percent) than among non-STEM students (45 percent).

Methodologically, we desired an indicator to understand how community college students attend school. Recent work (e.g., Crosta, 2014; Wang, 2014) on academic momentum suggests that we should examine students' intensity and continuity of community college

enrollment. To do so, we simplified Crosta's (2014) enrollment classification system[8] from six to four mutually exclusive categories:[9] mostly full-timers, mostly part-timers, early leavers, and long-term attachers. *Mostly full-timers* enroll full-time for at least 50 percent of enrolled semesters for between two to eight semesters; *mostly part-timers* enroll part-time for at least 50 percent of enrolled semesters for up to eight semesters; *early leavers* enroll for only one semester; and *long-term attachers* enroll for nine or more semesters, whether consecutively or intermittently. Summary statistics for these are listed under "Enrollment pattern" in the table.

Academically, STEM and non-STEM students are similar. On average, STEM students enrolled with slightly higher intensity (i.e., more enroll as full-timers), while the non-STEM population had more students leaving early in their community college careers. STEM and non-STEM students took about 1.4 developmental courses, and about one third failed a developmental course at least once. One fifth of students in both groups earned at least one credential within four years of initial enrollment. Even when disaggregated by enrollment pattern (not shown in Table 2), completion and transfer rates for STEM and non-STEM students are similar. For example, about 70 percent of both STEM and non-STEM students categorized as mostly full-timers did not earn a credential, and 88 percent of STEM and non-STEM students categorized as mostly part-timers did not earn a credential.

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[8] Crosta's (2014) classification system included full-time persisters (who enroll primarily full-time), early leavers (who typically leave after one semester), early persistent switchers (who change intensity often), mostly part-timers (who enroll primarily part-time), early attachers (who enroll for several consecutive semesters with frequent switches in enrollment status), and later attachers (who enroll for several semesters with frequent switches in enrollment status, but less continuously than early attachers).

[9] These categories are inclusive of all students who enroll, regardless of completion status. For example, a student who enrolls in a course and continues to enroll on and off for 15 continuous semesters is included as a long-term attacher, regardless of whether a credential is obtained by the student.

Table 2: Descriptive Statistics for STEM and Non-STEM Students

Variable	STEM Students N	Sample Mean (N = 48,081)	Non-STEM Students N	Sample Mean (N = 92,890)
Female	23,166	0.48	52,866	0.55
Race				
White	30,097	0.63	55,515	0.61
African American/Black	10,990	0.23	20,950	0.23
Asian	2,670	0.06	5,752	0.06
Hispanic	2,661	0.06	6,822	0.07
Unknown	1,391	0.03	3,348	0.04
Age at first enrollment	48,081	21.74	92,890	21.96
25 and under	39,571	0.82	76,548	0.82
Over 25	8,510	0.18	16,342	0.18
Over 40	1,955	0.04	4,733	0.05
STEM classification				
Traditional	24,237	0.17		
Allied health	12,263	0.09		
Technology/technician	11,581	0.08		
Persistence and graduation status				
Earned CC credential (within 18 semesters)	9,616	0.20	17,649	0.19
No credential after 9 semesters	40,869	0.85	78,957	0.85
No credential after 12 semesters	39,426	0.82	76,170	0.82
Transferred to 4-year institution (within 3 years of initial enrollment)	13,992	0.29	28,424	0.31
Enrollment pattern				
Mostly full-timer	19,121	0.40	33,189	0.36
Mostly part-timer	11,433	0.24	22,895	0.25
Early leaver	10,971	0.23	24,643	0.27
Long-term attacher	6,556	0.14	12,163	0.13
Developmental education				
Total developmental education courses	48,081	1.43	92,890	1.40
2+ developmental education courses	48,081	0.37	92,890	0.36
Ever failed developmental education course	48,081	0.34	92,890	0.34
Worked while enrolled	48,081	0.36	92,890	0.34
Financial aid				
Pell grant recipient	48,081	0.51	92,890	0.44
Expected family contribution ($)	48,081	5,351	92,890	5,275
Mean quarterly earnings in year 4 ($)	21,916	4,542	37,697	4,407

Notes. Calculations based on administrative data for first-time-in-college students who enrolled in the VCCS from 2004–2009. Enrollment pattern: Full-time persisters are those who typically enroll full-time, mostly part-timers are those who typically enroll part-time, early leavers are those who do not stay more than one semester, and long-term attachers are those who stay for at least 9 semesters.

When the descriptive statistics are examined by STEM category (Table 3), we find more notable differences, especially in terms of demography. For example, 83 percent of allied health program students are female, whereas only 12 percent of technology/technician program students are female. A comparison of age also finds that allied health and technology/technician program students tend to be older when compared to traditional STEM students—this difference is statistically significant. In terms of ethnic/racial composition, approximately 70 percent of both traditional and technology/technician students are White, a higher proportion than allied health programs (64 percent). Allied health programs contain significantly more Black students (28 percent) than the other two categories (approximately 18 percent each).

Academically, however, there are few substantial differences between students in the three STEM program categories. For example, the number of developmental education courses taken and failed is similar across the traditional, allied health, and technology/technician STEM programs. However, transfer rates do vary considerably across the three STEM program categories. Traditional STEM students, who are disproportionately enrolled in transfer programs, are almost two times as likely to transfer (37 percent) than their peers in allied health (20 percent), or technology/technician (13 percent) programs.

Table 3: Descriptive Statistics for Students by STEM Categories

Variable	Traditional STEM Sample Mean ($N = 16,985$)	Allied Health Sample Mean ($N = 5,958$)	Technology/ Technician Sample Mean ($N = 7,295$)
Female	0.49	0.83	0.12
Race			
White	0.71	0.64	0.69
African American/Black	0.28	0.28	0.18
Asian	0.04	0.03	0.04
Hispanic	0.05	0.03	0.06
Unknown	0.03	0.02	0.03
Age at first enrollment	20.6	23.4	22.8
25 and under	0.85	0.67	0.72
Over 25	0.11	0.27	0.23
Developmental education			
Total developmental educ. courses	1.6	1.5	1.2
Ever fail developmental education	0.37	0.3	0.3
Earned CC credential	0.2	0.21	0.17
4-year Transfer	0.37	0.2	0.13

Note. Calculations based on administrative data for first-time-in-college students who enrolled in the VCCS from 2004–2009.

In addition, a descriptive review of the mean quarterly earnings in the fourth year after initial enrollment (Table 4) shows that earnings are typically higher for STEM students than non-STEM students ($4,545 compared with $3,974). Despite the large differences in perceived academic requirements between STEM and non-STEM coursework, the student populations in this community college system are not vastly different—at least demographically and academically. That said, STEM students do appear to earn higher earnings in the short-term. In the following section, we begin to describe how we estimate more accurate earnings gains from STEM programs.

Table 4: Mean Quarterly Earnings of Completers by Credential Orientation and Program Category

	Overall		Career Orientation		Transfer Orientation	
Program Category	N	Earnings	N	Earnings	N	Earnings
Traditional STEM	13,092	$3,947.95	-	-	13,092	$3,947.95
Allied health	7,295	$4,570.79	6,876	$4,576.78	419	$4,485.41
Technology/technician	5,958	$5,826.74	5,694	$5,853.21	264	$5,255.91
Non-STEM	51,519	$3,974.27	32,972	$4,083.20	18,547	$3,780.61

Note. The table shows earnings during the fourth year after initial enrollment for students in the 2004–2009 VCCS cohorts who earned a certificate or associate degree and did not transfer. Traditional STEM students in career-oriented programs are excluded, as there were too few students for analysis.

3.4 Method for Estimating Labor Market Returns

Researchers have shown that Mincer and fixed-effects models can produce similar estimates (Dadgar & Weiss, 2012; Jepsen, Troske, & Coomes, 2014). Following labor market earnings studies by Belfield, Liu, and Trimble (2014), Jepsen et al. (2014), and Jacobson et al. (2005), we employ a Mincerian model to estimate returns to a community college credential. First, we compare mean earnings in the fourth year after initial college entry for students who earned a credential and those who earned at least one credit but did not earn any credentials within 9 quarters (i.e., four years). In addition, we control for covariates to develop models based on Mincer's (1958, 1974) principles[10] that allows us to estimate labor market returns for STEM students. Following the procedures employed by Belfield et al. (2014), we estimate the returns to specific community college academic outcomes using the following standard Mincerian equation:

$$Earnings = \alpha + \beta_1 Education + \beta_2 Experience + \beta_3 Experience^2 + \delta Z + \varepsilon, \qquad (1)$$

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[10] Jacob Mincer developed a popular single-equation model where earnings are explained as a function of schooling and experience. In most cases, logged earnings are modeled as the sum of years of education, years of work experience, and a quadratic of years of work experience.

In this equation, *Earnings* is the average quarterly earnings during students' fourth year after initial college enrollment and is a function of college education, *Education*, as indicated by award receipt; *Experience* is a measure of age at initial enrollment, which serves as a proxy for work experience; and *Z* is a vector of individual-level covariates, including enrollment patterns, age, gender, whether the student transferred, and other background variables. The coefficient of interest is $\beta 1$, an estimate of the earnings premium from credential receipt in community college. One key difference between our equation and the original Mincer equation is that we opted to use actual earnings[11] instead of log earnings, resulting in a change in interpretation. There are many instances where earnings of zero dollars were observed for students during a quarter; the log of zero would cause problems in our estimates.[12] While the Mincer equation simplifies our interpretation, the major limitation of the Mincerian method is that unobserved characteristics cannot be controlled for, and this may lead to underestimated returns to programs that enroll a significant number of low-performing students. This has been a primary reason why fixed effects have been used more and more frequently in research.

Our specification utilizes the general and most basic of Mincer's methods, which has been shown to produce generally reliable estimates. Recent estimations have added to this basic specification by proposing alternatives to separate out the returns to human capital accumulation and the signaling value of credentials.[13] For example, in their analysis using a similar dataset from the same community college system, Xu and Fletcher (in press) included separate terms for each portion by opting to denote the value of human capital as total credits accumulated and the value of signaling as credential receipt. Using their model, they found effects from both human capital and signaling on labor market returns. In this study, we do not separate the two effects, as this is solely a first attempt to utilize our framework in order to estimate the overall returns to a middle-level STEM credential.

An inherent weakness in our equation is that the extent to which $\beta 1$ is an unbiased estimator of the gains from credential receipt depends on the extent of two potential biases—omitted variable bias and selection bias. If a significant portion of observed earnings gains are a result of unobserved variables, or variables omitted from our equation and controls, our estimates will be biased upward (Arcidiacono, 2004; Brand & Xie, 2010). If a significant portion of observed earnings gains are a result of self-selection into college, when to enter the labor market, or where to work post-college, estimates will again be biased (Black, Kolesnikova, & Taylor,

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[11] We use real earnings, adjusted to 2010 dollars using the annual consumer price index from the Bureau of Labor Statistics website.

[12] For students for whom we observed labor market earnings in at least one quarter, who comprise our sample, we include any observed zero quarterly earnings. We conjecture that these zero-dollar earnings are more likely a result of unemployment or the choice to be unemployed in the market rather than unobserved earnings that could stem from out-of-region work or employment by a federal agency.

[13] The two major competing theories in the labor market returns literature are human capital theory (Becker, 1962; Rosen, 1976) and signaling theory (Spence, 1973). The first argues that individuals accumulate and improve skills through education, and that these added skills bring a return from the labor market. The latter argues that credentials give employers information about an individual's skills, and that the individual is rewarded in the labor market based on having credentials.

2009). While such biases may occur, the common method used to strengthen estimates is through robustness testing. Previous papers have found estimates using Mincer models to be highly robust (e.g., Dadgar & Weiss, 2012; Belfield et al., 2014). We include robustness checks in Section 4, "Robustness Checks."

While most scholarship on labor market outcomes strives to maximize longitudinal data sets, in this study, the focus is on short-term outcomes in order to inform a state- or regional-level strategy for developing a STEM workforce via community colleges. Extant research suggests that many community college students seek short-term credentials, and the extent to which these institutions serve as stumbling blocks or doors of opportunity for STEM workforce development in the near term has yet to be addressed. For some, the short-term time horizon may be considered a weakness; but short-term economic benefits are undoubtedly most relevant for low-income, low-skilled, underemployed, or unemployed people that are underutilized in their local economies. States and systems seeking to increase sub-baccalaureate STEM credential receipt may benefit from understanding which STEM programs do and do not provide graduates with short-term gains, directly informing alignment between economic and workforce development goals and community college offerings. That said, these estimates should be interpreted with caution, as longer-term benefits and credential receipt is not captured in this analysis. For comparability, we limit our sample for earnings gain estimations to students who were no longer enrolled during year four.

In order to calculate earnings gains, we must have both a treatment group and a comparison group. Whereas older studies have compared a postsecondary treatment group to a group of high school graduates who never enrolled in a postsecondary institution, more recent studies have identified more appropriate groups, given differences in survey data collection strategies related to postsecondary education. For example, some researchers have utilized a comparison group composed of a group of students who have completed credentials in another field. Jacobson and Mokher (2009) used humanities students as the comparison group. However, the goal of this paper is not to compare the values of STEM and non-STEM credentials, as it would perpetuate previously mentioned definitional issues that convolute outcomes and their interpretation. A more appropriate method for our purposes compares postsecondary students who earned a certificate or degree with those who earned college credits but no certificate or degree (e.g., Belfield et al., 2014; Dadgar & Weiss, 2012; Jepsen et al., 2014). In this paper, we follow the method used by Belfield et al. (2014), in which the control group is composed of individuals who completed at least one credit. This method provides comparable evidence to recent studies of labor market outcomes in community colleges.

4. Results

Overall Quarterly Earnings Gain Results

For our Mincer analyses, we compare the results of STEM students who obtained at least one credential from the VCCS to STEM students who obtained at least one credit at a VCCS college but no credential (transfer students are controlled for).[14] Credential status is based on the highest award obtained within the time period. Estimates are based on the average of non-missing quarterly earnings from the 12th to 16th quarters, or the fourth year after initial enrollment, and are reported as actual earnings increases and decreases per quarter in 2010 dollars. We report three stepwise specifications to show the effects of covariates and report estimates separately by gender, credential orientation, and STEM program category.

Table 5 presents a summary of the three models. This table shows the earnings gain for male and female students who earned credentials, compared with male and female students who ever earned at least one credit, in terms of earnings during the fourth year after initial enrollment. Our preferred specification is the third specification, which includes controls for background characteristics, such as age and race/ethnicity; college fixed effects; ability in college, with developmental math course-taking serving as a proxy; dummies for enrollment patterns; and dummies for whether the student was still enrolled in college during the fourth year in which earnings were measured. To minimize the effects of the Great Recession, we also ran specifications with quarterly fixed effects. As with the estimates of the labor market returns to community college credentials from Belfield et al. (2014) and Jepsen et al. (2014), the inclusion of full set of covariates does not substantially change the coefficients.

Across all models, Table 5 shows primarily mixed or slightly positive short-term earnings gains for STEM students whose highest credential obtained is a certificate. It is surprising that short-term returns to certificates are not more substantial, given Xu and Trimble's (2014) recent findings.[15] Certificates, which tend to be vocational credentials, should theoretically give students the skills needed to attain strong short-term labor market gains. Recent evidence points to declining benefits to these credentials over time (for example, Belfield et al., 2014, found negative returns in the medium term, or nine years after initial enrollment), as any benefits derived from these degrees likely occurs in the short-term, when skills learned are most useful. However, even assuming the returns to certificates fade over time, the expectation would be that some of the positive human capital effects would still be apparent during the fourth year after initial enrollment. Associate degrees, on the other hand, show consistently positive and mostly significant returns. The limitation of this table is that labor market returns are shown for all STEM students; yet, as we noted earlier, traditional, allied health, and technology/technician students are fairly different in terms of observable covariates. We follow this analysis by presenting differences first by credential orientation, then by STEM categories.

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[14] We add a dummy for those students who transferred to four-year colleges.
[15] Unlike Xu and Trimble (2014), we do not differentiate between short- and long-term certificates.

Table 5: Quarterly Earnings Gains Four Years After Initial Enrollment

	Men (n = 16,736)			Women (n = 16,670)		
	(1)	(2)	(3)	(1)	(2)	(3)
Highest award attained						
Certificate ($)	22	31	65	-21	16	80
	[70]	[60]	[73]	[93]	[93]	[83]
Associate degree ($)	63	203***	256***	150***	187***	334***
	[91]	[90]	[80]	[37]	[41]	[88]
Controls included in model						
Background characteristics		X	X		X	X
College characteristics		X	X		X	X
Ability		X	X		X	X
Non-enrollment condition		X	X		X	X
Quarterly fixed effects		X	X		X	X
Enrollment patterns			X			X

Note. Sample includes all first-time-in-college students who initially enrolled in the VCCS from 2004–2009 and initially chose a STEM subject as major. Returns shown are based on the average of non-missing quarterly earnings in the fourth year after initial enrollment and are adjusted for inflation to 2010 dollars. Comparison group is students who earned at least one credit but no credential. Robust standard errors are reported in brackets.

*p < .1. **p < .05. ***p < .01.

Table 6 shows the analysis by credential orientation within STEM. This table shows the earnings gain for students whose highest credential is an associate degree or certificate, compared with students who gained at least one credit in the same credential orientation during the fourth year after initial enrollment. For our chosen specification, three observations stand out. First, the labor market returns of STEM career program credential holders are consistently higher for associate degrees than for certificates; whereas returns for certificate holders are well less than $100 and not statistically significant, students who earned associate degrees have positive and significant short-term earnings gains of $450 to $480. Second, benefits are higher for women than men. For STEM career programs, benefits are higher for women than men at both at the certificate level (by $11) and associate degree level (by $30). For transfer-oriented graduates, the same is true (by approximately $450). These results are consistent with prior research using both more dated (Grubb, 2002; Grubb et al., 1997) and contemporary data (Belfield et al., 2014). Third, transfer students have consistently negative and significant coefficients; they seem to struggle in the labor market despite an analysis that controls for both students who are still enrolled at the time and students who have transferred to four-year universities. However, since these specifications do not include interaction terms with transfer status, these estimates are solely an aggregate across both those who transfer and those who do not.

To learn more about students who choose not to transfer to a four-year university, Table 7 shows estimates of our preferred specification when we restrict our sample solely to students who credentialed yet elected not to transfer to a four-year university. We show the estimates by transfer and career program orientation. In theory, both sets of students would enter the labor market after earning a credential, yet we find a strong contrast in labor market returns between transfer and career program students. Transfer program students who obtained an associate degree and chose not to transfer had significantly negative earnings gains relative to their non-credentialing peers, whereas career program students who obtained an associate degree received significantly positive earnings gains. For both men and women, these differences amount to over $700 in quarterly earnings.

At this time, we cannot properly estimate the labor market returns to associate degrees among students who transferred because they are, for the most part, still enrolled at the four-year college in their fourth year and have not yet fully entered the labor market. Thus, we do not have sufficient evidence to state that it is more beneficial to earn a career-oriented credential. However, our analysis between transfer and career orientation suggests that career program students experience significantly higher benefits than do transfer program students who choose not to transfer. The benefit we found is particularly strong for students who earn associate degrees, with non-statistically significant results for certificate-earners. Additionally, associate-level students studying in transfer-oriented credential programs, regardless of whether they transfer or not, show consistently negative short-term earnings gains within the four-year time horizon after initial enrollment.

Table 6: Quarterly Earnings Gains by STEM Program, Credential Orientation and Gender

	Men			Women		
	(1)	(2)	(3)	(1)	(2)	(3)
STEM Transfer Programs						
Highest award attained[a]						
Associate degree ($)	-316**	-888***	-911***	-778***	-557***	-462***
	[187]	[191]	[189]	[222]	[180]	[178]
Controls included in model						
Background characteristics		X	X		X	X
College characteristics		X	X		X	X
Ability		X	X		X	X
Non-enrollment condition		X	X		X	X
Quarterly fixed effects		X	X		X	X
Enrollment patterns			X			X
N (students)	11,021	11,021	11,021	11,382	11,382	11,382
STEM Career Programs						
Highest award attained						
Certificate ($)	23	208	70	-21	68	81
	[138]	[186]	[198]	[159]	[158]	[180]
Associate degree ($)	110	428***	450***	219***	417***	480***
	[72]	[66]	[91]	[58]	[83]	[80]
Controls included in model						
Background characteristics		X	X		X	X
College characteristics		X	X		X	X
Ability		X	X		X	X
Non-enrollment condition		X	X		X	X
Quarterly fixed effects		X	X		X	X
Enrollment patterns			X			X
N (students)	8,348	8,348	8,348	8,144	8,144	8,144

Note. Sample includes all first-time-in-college students who initially enrolled in the VCCS from 2004–2009 and initially chose a STEM subject as major. Returns shown are based on the average of non-missing quarterly earnings in the fourth year after initial enrollment and are adjusted for inflation to 2010 dollars. Comparison group is students who earned at least one credit but no credential. Robust standard errors are reported in brackets.

[a]There are no transfer-oriented certificate programs.

p < .1. ***p* < .05. ***p* < .01.

Table 7: Students Who Earned a Credential But Did Not Transfer: Quarterly Earnings Gains by STEM Program, Credential Orientation, and Gender

	Men	Women
	STEM Transfer Programs	
Highest award attained[a]		
Associate degree ($)	-402***	-371***
	[149]	[147]
N (students)	4,827	4,980
	STEM Career Programs	
Highest award attained		
Certificate ($)	153	201
	[256]	[354]
Associate degree ($)	327***	401***
	[132]	[151]
N (students)	1,420	1,321

Note. Sample restricted to all first-time-in-college students who initially enrolled in the VCCS from 2004–2009 and initially chose a STEM subject as major and limited to those who did not transfer to a four-year university. Returns shown are based on the average of non-missing quarterly earnings in the fourth year after initial enrollment and are adjusted for inflation to 2010 dollars. Comparison group is students who earned at least one credit but no credential. Preferred Specification is used. Robust standard errors are reported in brackets.

[a]There are no transfer-oriented certificate programs.

p < .1. **p* < .05. ***p* < .01.

Table 8 shows earnings gain estimates by STEM program type. This table shows the earnings gain for students who earned a credential from each STEM program category, as compared with students who gained at least one credit in the same program category during the fourth year after initial enrollment. Again, we find that both men and women who obtain an associate degree in an allied health or technology/technician STEM program have significant, positive, and relatively high earnings gains for our preferred specification. Results show earnings gains of between $381 and $686 per quarter for these students, suggesting that there may be good demand for these vocational workers or that sufficient human capital is gained during the course of enrollment to obtain a short-term earnings increase in the labor market. In prior analyses, students in allied health and technology/technician STEM fields consistently show larger short-term gains than do students in traditional STEM fields; the same is true here. Traditional STEM students have negative returns to their degrees. As in our previous analysis just above, these estimates reflect the fact that a majority of traditional STEM graduates (79 percent) are in transfer-oriented programs. Additionally, estimates show that both men and women have negative short-term returns from earning a traditional STEM credential. The

Table 8: Quarterly Earning Gains by STEM Program Category

|	Men			Women		
	(1)	(2)	(3)	(1)	(2)	(3)
Traditional STEM						
Highest award attained						
Certificate ($)	-23	-67	-12	-103	-91	-42
	[52]	[51]	[69]	[82]	[75]	[73]
Associate degree ($)	-361***	-732***	-728***	-108*	-157***	-156***
	[33]	[188]	[181]	[78]	[77]	[69]
Controls included in model						
Background characteristics		X	X		X	X
College characteristics		X	X		X	X
Ability		X	X		X	X
Non-enrollment condition		X	X		X	X
Quarterly fixed effects		X	X		X	X
Enrollment patterns			X			X
N	9,942	9,942	9,942	10,866	10,866	10,866
Allied Health						
Highest award attained						
Certificate ($)	32	45	54	33	202***	220***
	[88]	[83]	[81]	[88]	[82]	[79]
Associate degree ($)	188*	551***	587***	216**	521***	533***
	[92]	[87]	[101]	[102]	[90]	[90]
Controls included in model						
Background characteristics		X	X		X	X
College characteristics		X	X		X	X
Ability		X	X		X	X
Non-enrollment condition		X	X		X	X
Quarterly fixed effects		X	X		X	X
Enrollment patterns			X			X
N	1,396	1,396	1,396	7,210	7,210	7,210
Technology/Technician						
Highest award attained						
Certificate ($)	-83	-206**	-250**	29	-16	-20
	[61]	[112]	[115]	[95]	[89]	[87]
Associate degree ($)	87	676***	686***	182**	353***	381***
	[92]	[97]	[103]	[91]	[93]	[116]
Controls included in model						
Background characteristics		X	X		X	X
College characteristics		X	X		X	X
Ability		X	X		X	X
Non-enrollment condition		X	X		X	X
Quarterly fixed effects		X	X		X	X
Enrollment patterns			X			X
N	6,412	6,412	6,412	842	842	842

Note. Sample includes all first-time-in-college students who initially enrolled in the VCCS between 2004–2009 and initially chose a STEM subject as major. Returns shown are based on the average of non-missing quarterly earnings in the fourth year after initial enrollment and are adjusted for inflation to 2010 dollars. Comparison group is students who earned at least one credit but no credential. Robust standard errors are reported in brackets.

*p < .1. **p < .05. ***p < .01.

robustness of this observation holds regardless of age, gender, and various other background variables.[16]

Further, analysis by demographic subgroup yields an additional finding: Age at first enrollment is a significant determinant of earnings gains. Most students who began their community college enrollment at or after the age of 25 had significantly larger earnings gains than those who began under the age of 25 (see Figure 1). This supports other research, and suggests that unobservable characteristics of older students (e.g., maturity and work experience) likely contribute considerably toward short-term earnings gains.

Figure 1: Quarterly Earnings Gains by Age and STEM Program Type, Four Years After Initial Enrollment
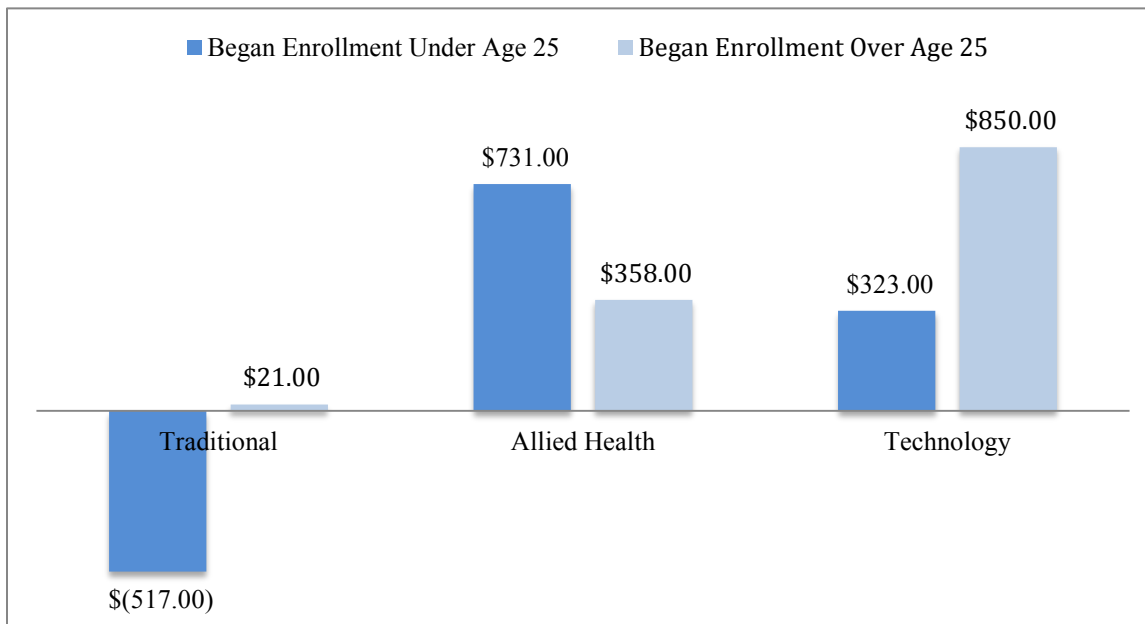
Note. Sample includes all first-time-in-college students who initially enrolled in the VCCS from 2004–2009 and initially chose a STEM subject as major. Estimates represent real earnings based on historical annual calculations of the consumer price index. Estimates utilize preferred specification from the text and restricted samples by age. All estimates are significant at the p < .05 level.

Robustness Checks

As a robustness check, we compare the Mincer estimates with fixed-effects estimates. Much of the recent research on labor market returns uses either a Mincerian model or a fixed-effects model, so similar estimates across strategies would give us more confidence in our results. In contrast with the Mincerian model, which employs a cross-sectional dataset, a fixed-effects model uses panel data to examine changes over time. The perceived advantage of using a fixed-effects model rather than a Mincerian model is that it takes into account the change in earnings gains over time, as opposed to earnings at one point in time. However, estimates that

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[16] Results from subgroup analyses comparing students with varying background characteristics are not presented here.

use longitudinal data, such as fixed-effects models, in the labor market literature also tend to be biased downward (Freeman, 1984).

Using an individual fixed-effects model, we control for the same variables using the same set of students. Table 9 shows the comparison between the Mincer and fixed-effects models. In general, the Mincer model produces slightly higher estimates than the fixed-effects model. The differences between the models, in terms of the magnitude and significance of the effects, are small. While the results are similar, the higher Mincerian estimates suggest that the students who obtain a credential are positively selected compared with students who only earn some credits. Yet the fact that there are only small differences suggests that our results are broadly comparable to studies primarily using the fixed-effects strategy.

A second issue concerning validity is the sample timeframe; many graduates in the sample reached the labor market during the Great Recession resulting in potential downward bias of estimates. As another test of robustness, we analyzed whether quarterly earnings estimates are sensitive to variation in graduation timing. We ran our preferred specification for the first two cohorts (2004 and 2005)—many students in these cohorts who earned a credential did so during recession—and compared the estimates to the last four cohorts (2006–2009). Again, the comparison showed no substantial differences in sign, magnitude, or significance regardless of whether the analysis was completed at the credential orientation level or the program category level. Results are not shown here.

Table 9: Quarterly Earnings Gain Estimates from Mincerian and Individual Fixed-Effects Models

Highest Award Attained and Transfer Status	STEM Transfer Programs Only				STEM Career Programs Only			
	Men		Women		Men		Women	
	Fixed Effects	Mincer	Fixed Effects	Mincer	Fixed Effects	Mincer	Fixed Effects	Mincer
Certificate ($)	N/A	N/A	N/A	N/A	72	70	116	81
					[183]	[198]	[171]	[180]
Associate ($)	-1,071***	-911***	-674***	-462***	347***	450***	408***	480***
	[138]	[189]	[133]	[178]	[92]	[91]	[109]	[80]
N (students)	19,322	8,322	21,092	8,592	19,847	8,348	20,293	8,144

Note. Sample includes all first-time-in-college students who enrolled in the VCCS from 2004–2009 and initially chose a STEM subject as a major. Returns are based on the average of non-missing quarterly earnings in the fourth year after initial enrollment and are adjusted for inflation to 2010 dollars. Comparison group is students who earned at least one credit but no credential. Estimates for Mincer were based on preferred specification. Standard errors are reported in brackets.

*p < .1. **p < .05. ***p < .01.

Considerations for the VCCS

In an attempt to translate the study's findings into information that could be used by the VCCS and state of Virginia, we conducted an analysis of each STEM program category and identified the three programs of study in each that are associated with the highest short-term earnings gains at the associate degree level. These results are summarized in Table 10. Results for certificates were not included due to small sample sizes.

Several observations stand out. First, only two of the nine programs with the highest quarterly earnings returns four years after initial enrollment are transfer programs. Second, 20 of the 23 VCCS institutions offer at least one of these nine programs associated with higher earnings. This suggests that most Virginians are near a VCCS campus that offers programs that will lead to relatively high short-term earnings gains. Third, computer science transfer programs that lead to a bachelor's degree are offered in only two VCCS institutions. Given the interest in expanding computer science within Virginia's K-12 schools[17] and producing more computer science bachelor's degrees nationally,[18] this may be problematic.

Although this analysis is limited somewhat by missing earnings data, it may provide Virginia and the VCCS with an example of areas to consider when determining their STEM-related economic development priorities using postsecondary and labor market data. For example, the three VCCS institutions that do not offer any of the programs noted in Table 10 are situated in areas with relatively high unemployment and low personal income compared with other parts of the state.[19] This study can help (further) induce conversations about the dynamic interplay between local community colleges and workforce development strategies associated with STEM. In fact, given that VCCS student enrollment in STEM programs increased by 50 percent between 2004 and 2009 suggests that students may be interested in reaping the often touted earnings benefits of STEM credentials. Yet, understanding what this means given community colleges' multiple missions is critical for supporting their success. For example, technical studies programs, which offer some of the highest sub-baccalaureate career program returns in the VCCS, are specifically tailored to each campus with input from local employers.[20] Understanding how to provide this type of curricular responsiveness to more VCCS institutions may be key to workforce development strategies in more idiosyncratic localities. In addition, given that many community college students initially aspire to earn bachelor's degrees (Santos Laanan, 2003), this study suggests a need to better help facilitate transfer to four-year institutions with financial support since short-term returns to STEM transfer credential are negative, whether students successfully transfer or not.

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[17] See http://www.doe.virginia.gov/testing/sol/standards_docs/computer_technology/
[18] See Kaczmarczyk and Dopplick (2014).
[19] See Council on Virginia's Future (2013).
[20] See http://www.courses.vccs.edu/programs/major/718.TECHNICALSTUDIES.

Table 10: VCCS Associate Degree STEM Programs with the Highest Quarterly Earnings Returns

Program Type	VCCS Offerings	Credential Orientation	Quarterly Earnings Gain Estimate ($)
Technology/technician			
Technical studies	11	Career	1,038.3
Computer electronics technology	7	Career	596.8
Machine shop	2	Career	523.3
Allied health			
Physical therapist assistant	3	Career	773.3
Veterinarian technology	2	Career	589.6
Medical laboratory technology	5	Career	529.2
Traditional STEM			
Computer software specialist	1	Career	192.4
Computer science	3	Transfer	163.1
Engineering	8	Transfer	74.2

Note. Quarterly earnings gains estimated based on full preferred specification, grouped by program enrollment for 2004–2009 VCCS cohorts. Only associate degree programs are included. Programs with less than 50 total students are excluded.

5. Discussion and Conclusion

Various stakeholders in government, industry, and philanthropy have an interest in increasing the number of postsecondary credential recipients with STEM skills. Community colleges are increasingly being recognized as a critical mechanism for meeting that goal, as evidenced by the significant growth in STEM credentials at the VCCS between 2004 and 2009. Yet, research to date has provided little insight on STEM programs at community colleges in a systematic way, or in a way that is responsive to students' short-term economic needs. By providing a classification scheme for STEM programs that is attentive to credential type, credential orientation (transfer or career), and program category (traditional, allied health, or technology/technician), the current study establishes a framework for defining and discussing STEM programs at community colleges.

Using that classification scheme, our analysis of data from the VCCS investigated the STEM programs of study, credential types, and credential orientations that are most relevant at the sub-baccalaureate level; whether STEM students are significantly different from their non-STEM peers; and how short-term labor market outcomes are influenced by STEM credential receipt. While most extant research shows that over a lifetime, individuals with STEM credentials earn more money (Carnevale, Smith, & Melton, 2011), students attending community colleges tend to be sensitive to time, likely making short-term credentials and economic benefits a priority (Xu & Trimble, 2014). Our analysis adds to the evidence that STEM and non-STEM students *may* earn similar short-term earnings when STEM programs are not disaggregated. But a closer look at particular STEM program types suggests that completing certificates and associate degrees in allied health and technology/technician fields results in higher short-term earnings than completing traditional STEM programs of study (see also Carnevale, Smith, & Strohl, 2010; Rothwell, 2013). As in Belfield and Bailey's (2011) review, there were also relatively consistent gender differences in earnings benefits, with women generally accruing larger benefits for both certificates and associate degrees.

We also find that a program's credential orientation influences student earnings, with students in career-oriented programs reaping larger benefits within four years than students in transfer-oriented programs. This is at least partially due to the combination of valuable vocational skills learned by those in career-oriented programs and the likelihood of students in transfer-oriented programs being younger, having less work experience, and having lower prior earnings. Additionally, after controlling for students who are still enrolled in either community college or a bachelor's program and running an analysis restricting the sample to students who earn a credential but do not transfer, we find that those students from transfer-oriented programs, particularly traditional STEM students, have smaller short-term earnings gains in the labor market than their peers following career-oriented pathways. This may be a result as many traditional STEM students graduating from transfer programs require a successful transfer to a four-year college in order to fully realize eventual labor market gains. For example, a science or engineering student prepared for entry to a four-year college that falls short of transferring may

find that his or her skills are less competitive in the labor market than (a) peers from career programs, who prepare directly for certain jobs, and (b) traditional STEM peers who transfer to four-year colleges to pursue bachelor's degrees. The labor market for science or engineering jobs often requires a minimum of a bachelor's degree, and so not transferring represents a critical decision that limits short-term labor market returns. And so it must be emphasized that bachelor degree attainment for such students is of great importance.

It is important to note that in recent years the VCCS has been attentive to articulation agreements[21] with both private and public four-year institutions, which facilitate automatic transfer as long as students meet minimum GPA and degree requirements. These agreements may indeed facilitate transfer, as 57 percent of VCCS STEM students in transfer programs who met basic requirements[22] did transfer to a four-year institution eventually. However, it is unclear why many students who, despite meeting minimum qualifications, still fail to transfer. Given that older STEM students in our study experienced larger earnings gains, additional work should investigate the extent to which institutions, including the VCCS, can better support younger students choosing longer term transfer-oriented programs since short-term benefits are practically nil.

One suggestion may be to increase STEM employer engagement early on, such that students understand the career pathways associated with their chosen field of study and can find relevant work opportunities that will reward their persistence to completion of two- or four-year credentials. Additional analysis of VCCS STEM students' industry of employment four years after initial enrollment (regardless of whether they earned a credential) reveals that 42 percent of students from allied health programs worked in directly related industries—general hospitals, dental offices, physician offices, home health care services, and veterinary services. In contrast, students enrolled in traditional STEM programs, such as science or engineering, found work in a wider range of industries. Over 20 percent of traditional STEM students found work in restaurants; a significant portion of these students intended a science major (but lacked a credential four years after initial enrollment). Although the data from the U.S. Census Bureau's North American Industry Classification System used for this analysis does not differentiate between specific occupations in these workplaces, it does provide support for research suggesting that economic returns are highest when program of study and industry are aligned (see, e.g., Carnevale, Rose, & Cheah, 2011).

Use of the federal work-study program could be especially helpful in this type of effort, given that community college students are already likely to work (see Scott-Clayton & Minaya, 2014). Acknowledging that STEM transfer programs have unattractive short-term labor market

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[26] Articulation agreements are partnerships between community colleges and four-year universities that typically provide two-year students a simplified and guaranteed transfer as long as certain academic criteria are met. In Virginia, articulation agreements generally require students to have a minimum GPA ranging from 2.0 to 3.6 and to have earned a credential with a transfer-oriented associate degree prior to transfer. For examples of articulation agreements in Virginia, see http://www.vccs.edu/students/transfers/.

[22] The *most* basic requirements are usually a 2.0 GPA and a transfer-oriented associate degree.

outcomes may also motivate colleges and communities to develop better ways to promote persistence, if STEM bachelor's degrees are part of completion and workforce development goals.

Finally, given the rhetoric surrounding STEM and the academic exceptionalism of students who choose these fields (that admittedly is associated with four-year STEM students), it is notable that few significant differences exist between STEM and non-STEM community college students in terms of academic preparation, enrollment patterns, and outcomes. While completion and transfer rates are less than ideal, the similarity of STEM and non-STEM students suggests that more students enrolled at community colleges are likely capable of completing sub-baccalaureate STEM programs. And while there has been much debate about STEM credential shortages, this study suggests that it is important to clarify the extent to which an increase in postsecondary STEM credentials is relevant for individual or societal economic benefits. Our analysis suggests that in the short-term, STEM career credentials are positive, but that sub-baccalaureate STEM credentials that should lead to four-year bachelor's degrees have limited benefits to students who are not able to transfer to a baccalaureate program. Nevertheless, given the longer-term benefits of STEM bachelor's degrees, understanding how to better support transfer-oriented community college STEM students in the short-term is critical.

Community colleges are well situated to prepare workers for middle-skill and professional STEM jobs. However, stakeholders must answer critical questions in order to develop an effective state or regional strategy for meeting their STEM workforce needs. For instance, what is the state or regional labor market for sub-baccalaureate STEM skills and (career- and transfer-oriented) credentials? At the institution level, earnings gaps between STEM program types (i.e., allied health, technology/technician, or traditional STEM), credential orientations (i.e., transfer or career), and younger and older students in the short-term may prompt significant policy questions. Do community college students obtain pre-enrollment or early enrollment guidance on the different STEM programs of study, credential orientations, and related opportunities for employment in the short and longer term? If so, is it effective in its current form? What kind of guidance could help ensure deliberate alignment between STEM students' educational and career goals and local labor market needs? How can community colleges, industry leaders, the federal government, and four-year colleges better support sub-baccalaureate STEM (and non-STEM) students in transfer-oriented STEM programs? How might messaging for recruitment into sub-baccalaureate STEM address differences in short-term labor market outcomes?

Given President Obama's recent call to make community college tuition free for low-income students who maintain a 2.5 grade point average, understanding how factors such as college cost and the need to work influence students' choices to pursue and complete sub-baccalaureate STEM credentials is critical, particularly given the relatively small differences between students who pursue STEM and non-STEM programs. This also raises the question of whether it is possible to more effectively incentivize students to pursue STEM programs or credential orientations given their *short-term* labor market outcomes. This study represents one

step toward providing researchers with a framework for organizing STEM programs, and one state with the opportunity to use that information as they develop a middle- and professional-skill STEM workforce.

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Appendix

Table A1: VCCS STEM Majors by Program Category and Credential Orientation

Program Major	Percentage of STEM Sample[a]	STEM Program Category	Credential Orientation	Associated CIP Codes
Science	18.09	Traditional	Transfer	30.0101
Nursing	14.77	Allied health	Career	51.3801
Health sciences	10.71	Allied health	Career	51.0999
Engineering	8.56	Traditional	Transfer	14.0101
Information systems technology	5.74	Tech/tech	Transfer	11.0101
Automotive	5.13	Tech/tech	Career	47.0604
Emergency medical services	2.9	Allied health	Career	51.0904
Air conditioning and refrigeration	2.48	Tech/tech	Career	47.0201
General engineering technology	2.02	Tech/tech	Career	15.0000
Computer aided drafting and design	1.89	Tech/tech	Career	15.1302
Computer science	1.87	Traditional	Transfer	11.0701
Practical nursing	1.83	Allied health	Career	51.3801
Fire science technology	1.6	Tech/tech	Career	43.0203
Computer electronics technology	1.58	Tech/tech	Career	15.0303
Radiography	1.53	Allied health	Career	51.0911
Technical studies	1.53	Tech/tech	Career	47.0105
Welding	1.47	Tech/tech	Career	48.0508
Hospitality management	1.34	Allied health	Career	52.0901
Electronics technology	1.14	Tech/tech	Career	15.0303
Architecture	0.93	Tech/tech	Career	15.1303
Diagnostic medical sonogram	0.88	Allied health	Career	51.0910
Architect civil engineer	0.85	Tech/tech	Career	15.0000
Physical therapist assistant	0.85	Allied health	Career	51.0806
Electricity	0.68	Tech/tech	Career	15.0303
Electrical electronics	0.6	Tech/tech	Career	15.0303
Medical laboratory technology	0.57	Allied health	Career	51.1004
Dental hygiene	0.52	Allied health	Career	51.0602
Health information technology	0.52	Tech/tech	Career	51.0707
Medical assisting	0.49	Allied health	Career	51.0799
Computer arts	0.46	Traditional	Career	11.0101
Computer networking technology	0.44	Tech/tech	Career	11.0101
Automotive analysis and repair	0.42	Tech/tech	Career	47.0604
Construction management technology	0.41	Tech/tech	Career	46.0000
Funeral service	0.33	Tech/tech	Career	12.0302
Mechanical engineering technology	0.33	Tech/tech	Career	15.0000
Respiratory therapy	0.33	Allied health	Career	51.0908

Program Major	Percentage of STEM Sample[a]	STEM Program Category	Credential Orientation	Associated CIP Codes
Veterinary technology	0.33	Allied health	Career	51.0808
Dental assisting	0.31	Allied health	Career	51.0601
Corrections science	0.29	Tech/tech	Career	43.0113
Machine shop	0.28	Tech/tech	Career	1.0205
Civil engineering technology	0.26	Tech/tech	Career	15.0000
Automotive technology	0.23	Tech/tech	Career	47.0604
Electronics engineering	0.2	Tech/tech	Career	15.0303
Instrumentation	0.2	Tech/tech	Career	14.0501
Mechanical design	0.2	Tech/tech	Career	15.1302
Occupational therapist assistant	0.18	Tech/tech	Career	51.0806
Computer integrated manufacturing	0.16	Tech/tech	Career	15.0613
Machine technology	0.16	Tech/tech	Career	1.0205
Mental health	0.15	Allied health	Career	51.0707
Computer software specialist	0.13	Tech/tech	Career	11.0101
Medical transcription	0.13	Allied health	Career	51.0799
Biotechnology	0.1	Allied health	Career	41.0101
Computer aided drafting and design	0.1	Tech/tech	Career	15.1302
Computer electronics technician	0.1	Tech/tech	Career	11.0101
Dental laboratory	0.1	Allied health	Career	51.0602
Environmental science	0.1	Tech/tech	Career	30.0101
Massotherapy	0.1	Allied health	Career	51.3501
Industrial maintenance	0.08	Tech/tech	Career	47.0201
Opticianry	0.08	Allied health	Career	51.1801
Electronics	0.07	Tech/tech	Career	15.0303
Precision machining technology	0.07	Tech/tech	Career	46.0000
Forest science	0.05	Tech/tech	Career	3.0501
Heavy equipment operation	0.05	Tech/tech	Career	1.0205
Industrial management	0.05	Tech/tech	Career	46.0401
Medical laboratory technology	0.05	Allied health	Career	51.1004
Printing	0.03	Tech/tech	Career	10.0305
Machine tool operations	0.02	Tech/tech	Career	1.0205
Microcomputer office automation	0.02	Tech/tech	Career	11.0601

Note. Majors listed are limited to those the authors deemed as belonging to STEM fields within the VCCS. This classification of STEM program categories was compiled based on conversations with community college researchers and practitioners, and within the research team. This list should be considered a guide rather than a rulebook for future research on STEM in community colleges.

[a] Percentage of STEM sample is calculated as the number of students in a STEM program category during the first semester of enrollment divided by the total number of students identified in one of the three STEM program categories at the time of their first semester of enrollment.