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Early Academic Momentum: Factors Contributing to Community College Transfer Students' STEM Degree Attainment

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Abstract

Guided by the notion of academic momentum, this study drew data from longitudinal transcript records at a large public 4-year research university and examined factors that specifically contribute to community college transfer students' academic momentum. It also explored how early academic momentum along with students' sociodemographic characteristics impact degree attainment in science, technology, engineering, and mathematics (STEM) fields of study. This study conducted multinomial logistic regression analysis and found that certain students' background characteristics (i.e., gender, age, and family income), community college academic achievement (i.e., associate degree completion, and number of community college credits accepted), and early academic performance at the 4-year university (math and English preparedness, number of credit hours attempted, and first-semester grade point average) were significantly related to transfer students' likelihood of obtaining a STEM degree. The findings provide new knowledge about academic momentum and

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could be used to enhance the community college pathway to STEM degree completion.

Keywords
early academic momentum, transfer students, STEM degree attainment

Community colleges have been widely recognized for their effort in providing affordable education and serving diverse student populations. Almost half (43.6%) of all undergraduate population in public higher education enrolled in community colleges (National Center for Education Statistics, 2018a). Community colleges make it possible for many students who historically have not had access to traditional 4-year institutions to pursue higher education because of its open access policy and low cost (Bailey, Jenkins, & Leinbach, 2005). These institutions play a particularly important role in serving minority populations, as 84% of first-time students in community colleges are racial/ethnic minorities (American Association of Community Colleges, 2016). Community colleges are also viewed as an integral component in science, technology, engineering, and mathematics (STEM) education and workforce development (Mooney & Foley, 2011; National Academies of Sciences, Engineering, and Medicine, 2016). Research has found positive evidence that community colleges provide a nurturing environment that encourages community college students to major in STEM (Allen & Zhang, 2016; Jackson, Starobin, & Laanan, 2013; Malcolm, 2010; Starobin, Smith, & Laanan, 2016).

Despite the promising opportunity of obtaining a STEM degree via the community college pathway, few community college students who aspire to obtain a 4-year degree transfer, and even fewer received a bachelor's degree. According to the national data, approximately 90% of students enrolled in community colleges intent to transfer to 4-year universities, but only about half indeed transferred and only 1 of 10 received a bachelor's degree within 6 years of initial entry to the college (Hoachlander, Sikora, & Horn, 2003).

For community college students who have successfully transferred, they tend to experience more challenges than their peers who begin directly at a 4-year university (Handel & Williams, 2012). The existing literature notes that transfer students often find that 4-year universities have higher academic standards, requires a faster pace of learning, and demands more effort on writing (Townsend, 2008). Transfer students also face challenges of loss of credits earned in community colleges, which could prevent them from obtaining a bachelor's degree in a timely manner (Monaghan & Attewell, 2015). In addition, transfer students may feel marginalized due to their transfer status

(Ogilvie & Knight, 2019; Owens, 2010; Reyes, 2011). The challenges can be even more severe for transfer students in STEM fields of study, because most of the 4-year STEM programs follow highly structured curricula and require students to progress in a restricted pathway (Cogdell, 1995; Wyner, Deane, Jenkins, & Fink, 2016; Zhang & Ozuna, 2015).

To better understand transfer students' experiences in STEM programs, researchers have examined factors contributing to transfer students' success in STEM, but most of these studies were conducted with a focus on students' transition and adjustment (e.g., Jackson & Laanan, 2015; Ogilvie & Knight, 2019; Packard, Gagnon, & Senas, 2012). It still remains unclear how transfer students' academic experiences, such as course-taking, academic load, and performance, at early stages impact their degree attainment in STEM fields of study. There are only a handful articles discussing these important variables—collectively referred as "early academic momentum" (Adelman, 1999, 2006; Chan & Wang, 2018; Goldrick-Rab, 2010; Wang, 2015, 2017), but none has focused on the transfer student population in STEM nor explored the relationship between early academic momentum and degree attainment. Thus, in this study, I focus on factors that uniquely contribute to transfer students' early academic momentum, including their academic achievements in community colleges as well as their first-semester academic performance in a 4-year public research university post transfer, and how these variables impact transfer students' degree attainment in STEM. In addition, I used students' sociodemographic characteristics in the analysis as they provide important context about transfers' backgrounds. Specifically, the guiding research question addressed in this study was the following: "to what extent do transfer students' sociodemographic characteristics, community college academic achievement, and first-semester academic performance at a 4-year university are associated with transfer students' STEM degree attainment?"

Conceptual Framework and Relevant Literature

This study was informed by the notion of academic momentum (Adelman, 1999, 2006), which provides an important perspective to explain degree completion, or incompletion, of students who attend higher education institutions. Adelman's (1999, 2006) research reveals that undergraduate students' high school background, initial academic course load, and progress at the college have a significant impact on their future academic trajectory and consequently, degree completion. He indicates that undergraduates who take certain courses and progress to graduation at a certain speed are more likely to complete a degree than those whose progress is slow or interrupted.

Built upon Adelman's (1999, 2006) work, Wang (2015) applied the notion of academic momentum particularly to the field of STEM education and focused on STEM degree completion. She defined early academic momentum as

"academic behaviors and efforts students exhibit in early STEM course work that propel them forward toward persistence and success in STEM fields of study" (p. 377). Wang examined this concept from three perspectives, including (a) number of STEM credits attempted in the first term in college, (b) quality points students received for their STEM courses, and (c) whether students enrolled in STEM courses during the first summer. Wang's study suggests that early STEM momentum is a strong predictor of later STEM academic outcomes. Although Wang's (2015) study provides invaluable insight into STEM degree completion, it does not consider student transfer status nor include factors that are particularly relevant to community college transfer students' pathways to degree completion.

To better understand early academic experiences of transfer students pursuing STEM and how they influence transfers' desired educational outcome in STEM, in the following section, I provide a thorough synthesis of literature mainly focusing on transfer students and STEM success. Overall, the current literature found the following factors that significantly impact students' educational outcomes.

Associate Degree

The current literature has shown mixed findings regarding the effect of earning an associate degree on students' bachelor's degree completion. On the one hand, evidence indicates that obtaining an associate degree has a positive association with community college students' likelihood to transfer to a 4-year university (e.g., Crook, Chellman, & Holod, 2012; Roksa & Calcagno, 2010) and their posttransfer academic success (e.g., Crook et al., 2012; Ehrenberg & Smith, 2004). For instance, using data drawn from the State University of New York, Ehrenberg, and Smith (2004) found that students with a transfer-oriented associate degree (AA/AS) were more likely to earn a bachelor's degree within 3 years than their counterparts without the degree. Similarly, Crook et al. (2012) reported that students from the City University of New York who received an AA/AS had a higher likelihood to graduate with a bachelor's degree. In a more recent study, Kopko and Crosta (2016) noted that AA/AS completers, when compared with the noncompleters, had higher bachelor's degree completion rates across different types of 4-year institutions (i.e., public, private, and private for-profit).

On the contrary, research indicates that reception of an associate degree prior to transfer has no effect on students' academic success in 4-year institutions. D'Amico, Dika, Elling, Algozzine, and Ginn (2014) suggest that obtaining an associate degree is not a significant predictor of transfer students' academic outcomes in the first and second semesters; it is neither a predictor of their enrollment in second and third semesters. Similarly, Wang, Chuang, and McCready (2017) found no significant differences between the associate

degree earners and nonearners regarding their degree attainment, retention, and grade point average (GPA) after transfer.

Credit Earned Prior to Transfer and Accepted by 4-Year Universities

The number of credits that students earned in community colleges is an important indicator of community college students' academic preparation for transfer and posttransfer success (Doyle, 2009; Hagedorn, Cypers, & Lester, 2008), but more importantly, is the number of credits that are accepted by the receiving 4-year university (Doyle, 2006). The number of community college credits accepted by the 4-year institution is found to be positively associated with transfer students' likelihood to obtain a bachelor's degree (Doyle, 2006; Monaghan & Attewell, 2015). According to Monaghan and Attewell (2015), the higher the percentage of the community college credits accepted by a 4-year university, the more likely the transfers are to graduate with a bachelor's degree. Specifically, the odds of graduation for students who have all or almost all their credits transferred are 2.5 times higher than those with less than half of their credits transferred.

However, the credit transfer process can be critically challenging for community college students, and it may lead to transfer credit loss, delay students' timely degree completion, and increase the cost for students, their families, and taxpayers (Fink, Jenkins, Kopko, & Ran, 2018; Monaghan & Attewell, 2015; U.S. Government Accountability Office, 2017). For instance, Monaghan and Attewell (2015) found one in seven students was unable to transfer almost all of the community college credits to 4-year institutions, which can significantly lower the likelihood of the students to obtain a bachelor's degree.

Coursework

Research has explored the relationship between coursework and the likelihood of community college students transferring to 4-year institutions, as well as students' persistence and graduation in STEM fields. For instance, Cabrera, Burkum, and La Nasa (2005) reported the number of mathematics and science courses completed as a strong predictor for transfer. In addition to the number of courses taken, Cohen and Kelly (2019) found the completion rate of mathematics and science courses to be significantly associated with community college student graduation or transfer. Similarly, Hagedorn and DuBray (2010) highlighted the importance of mathematics, English, and science coursework as gateway courses leading to transfer.

When discussing students' STEM persistence and retention, math preparation is particularly documented as a critical factor (Shaw & Barbuti, 2010). Although students who have high grades in math do not necessarily find it easy to study in a STEM program, the lack of mathematics skills almost

always lead to STEM dropouts and attrition. Chen and Soldner (2013) indicate that a higher proportion of students who left STEM fields (STEM leavers) at both the bachelor's and associate's degree level did not earn any math credits in their first year in college when compared with their peers who persisted in STEM (STEM persisters). On the contrary, the percentage of the STEM persisters who took calculus or advanced mathematics in the first year approximately doubled the percentage of the STEM leavers. Focusing on engineering transfers specifically, Laugerman, Shelley, Rover, and Mickelson (2015) found that credits earned in Calculus I and II at community colleges have a positive influence on transfers' retention and graduation.

Early College Academic Experiences

The review of the literature reveals that students' early academic experiences in college are critical for their later educational achievement. Most of the studies highlight the importance of students' enrollment intensity, academic load, and performance on students' transferability, persistence, and credential/degree completion.

Enrollment intensity. The existing research has shown that students' enrollment intensity is positively associated with desired educational outcomes (Adelman, 1999, 2006; Crosta, 2014; Driscoll, 2007). Adelman (1999, 2006) found from national data that students with less frequent full-time enrollment were less likely to obtain a bachelor's degree. Driscoll (2007) noted a strong correlation between students' first-semester enrollment intensity and their likelihood of persisting to the spring semester, transferring to a 4-year university, and earning a bachelor's degree. Similarly, Crosta (2014) explored the complexity of patterns of community college students' course-taking and enrollment intensity and concluded that students who enroll full time were more likely to transfer to 4-year universities.

Academic load. The academic load, which is often measured by the number of credit hours that students attempted or earned, has been well documented as an important predictor for students' academic outcomes, such as credential completion, degree attainment, or transfer to a 4-year institution (Calcagno, Crosta, Bailey, & Jenkins, 2007; Chan & Wang, 2018; Crosta, 2014; Mau, 2016). For instance, McCormick (1999) found that students who earned more credits in the first year obtained more credits overall in 4 years in college and tended to graduate with a bachelor's degree. More specifically, almost all students (91%) who completed 30 credits in the first year obtained a bachelor's degree, while less than half (45%) of those with more than 10 but fewer than 20 credits did so. In a more recent study focusing on STEM, Mau (2016) noted that the number

of credit hours earned in the first year was positively associated with persistence in STEM degree completion.

Academic performance. Students' academic performance is another important factor impacting students' transfer, persistence, and degree attainment for students in all majors and in STEM in particular. Most of the studies used the GPA to measure students' academic performance. For instance, the first-year GPA was found to be positively associated with students' retention (Rohr, 2012) and degree completion (Dowd, 2004; McCormick, 1999). Research targeting STEM students suggest similar results. That is, an increase in first-semester GPA is associated with an increase in the odds of persistence in STEM majors (Dika & D'Amico, 2016) and obtaining a STEM degree (Crisp, Nora, & Taggart, 2009).

Sociodemographic Characteristics

An extensive amount of research has examined the impact of sociodemographic characteristics, such as age, gender, race/ethnicity, and socioeconomic status (SES), on students' academic success in general and particularly in STEM. Researchers have found disparities in academic achievement by age differences. From a qualitative perspective, Allen and Zhang (2016) found that older transfer students in engineering programs were less inclined to interact with younger peers and removed from engaging in out-of-class experiences and learning opportunities due to conflicts between work and school schedules. Moreover, Mau (2016) indicated that younger students were more likely than their older peers to persist in a STEM major.

A large body of literature found that female students were less likely to declare a STEM major or obtain a STEM degree than their male peers (e.g., Crisp et al., 2009; Mau, 2016; Moakler & Kim, 2014; Tyson, Lee, Borman, & Hanson, 2007; Wolniak, 2016). Although the proportion of female aspired to a STEM degree (excluding social sciences) has been increasing (Eagan, Hurtado, Figueroa, & Hughes, 2014), male recipients of STEM bachelor's degree still outnumber females, and the difference is especially pronounced in certain majors. For instance, only about one fifth of bachelor's degrees in computer and information science and engineering were awarded to females (National Center for Education Statistics, 2018b). However, researchers in a more recent study of community college transfers reported that female transfers were less likely than males to express interests in pursuing a STEM degree, but those who did choose a STEM major were indeed more likely to complete a STEM degree (Zhang, Adamuti-Trache, & Connolly, 2019).

The literature also reveals disparities in STEM intention and degree attainment across racial/ethnic groups. Numerous studies have shown that Asian Americans are more likely to pursue a STEM major and graduate with a degree in STEM (e.g., Crisp et al., 2009; Zhang et al., 2019), while some note

that Black and Hispanic students are equally as likely to declare a STEM major as their White or Asian American counterparts (Moakler & Kim, 2014). Wang, Chan, Soffa, and Nachman (2017) suggest that Black women are less likely than White women to have the intent to transfer into STEM fields of study nor receive a STEM degree. Similarly, Rincon (2017) indicates that Black and Hispanic women are the least likely to choose an engineering or computer science major.

In addition, research has found that students' SES background exerts an important impact on their decisions to pursue a STEM degree and STEM degree completion (e.g., Kruse, Starobin, Chen, Baul, & Laanan, 2015; Leslie, McClure, & Oaxaca, 1998; Niu, 2017). Students with a higher SES background are more likely to enter STEM fields and graduate with a STEM degree (Eagan, Hurtado, & Chang, 2010; Zhang et al., 2019). Students whose parents received higher levels of education tend to express an intent to transfer to 4-year STEM programs (Kruse et al., 2015). On the contrary, first-generation students are more likely to drop out of community college, not mentioning transferring to a 4-year institution (Crisp & Delgado, 2014). Students with greater financial concerns are less likely to obtain a STEM degree (Eagan et al., 2010).

In summary, the review of the relevant literature provides a thorough overview for this study regarding important factors that are associated with college students' desired educational outcomes. The review also indicates a limitation in the current literature. Prior studies either focused only on community college students' success without considering their major differences, or studied students in STEM fields without incorporating transfer status in the analysis. Thus, to address the gap in the literature, I investigated specifically community college transfers and examined the relationships between their STEM degree completion and variables uniquely applicable to this particular student population.

Methods

Research Site, Data Source, and Sample

The data used in the study were drawn from longitudinal student transcript data collected from transfer students enrolled in a 4-year public research university in the Dallas-Fort Worth metroplex (pseudonym, UDFW). UDFW has been recognized in the nation for its large number of transfer students. It ranked by the U.S. News and World Reports as one of the top universities in the nation in new transfer student enrollment.

The dataset tracks a cohort of community college students who first entered UDFW in Fall 2006 over a decade (from Fall 2006 to Summer 2016). The community college transfer students in this study were defined by the type of the last institution that the students attended prior to their enrollment in UDFW. That is, students who attended a community college immediately

before enrolling in UDFW were defined as community college transfer students. As international students often have different experiences, this study focuses only on domestic students. In total, the sample includes 2,057 community college transfer students.

Variables and Measures

Dependent variable. Community college transfer students' degree attainment within 10 years of initial enrollment in UDFW serves as the dependent variable in the multinomial logistic regression (MLR) model. More specifically, this variable explains whether, by the summer of 2016, community college transfers who matriculated at UDFW in Fall 2006 had earned a bachelor's degree in a STEM field (thereafter *STEM BA completers*), obtained a bachelor's degree in a non-STEM field (thereafter *non-STEM BA completers*), or did not receive a bachelor's degree (thereafter *noncompleters*). In the sample, about 11% were identified as STEM BA completers, 45% non-STEM BA completers, and 43% noncompleters. As a categorical variable with three levels, this degree attainment variable is appropriate to be used as the dependent variable in the MLR model. In this study, STEM majors included science (e.g., biology, physics, chemistry), engineering (e.g., aerospace engineering, civil engineering, electrical engineering), mathematics, computer science, and architecture. The other majors were defined as non-STEM.

Independent variables. Based upon the early academic momentum literature, findings from studies of STEM success and transfer students' experiences and the availability of the variables in the dataset, I selected the following groups of variables as independent variables in the MLR model: community college transfers' sociodemographic backgrounds, community college educational achievement, and early academic performance at UDFW. More specifically, the students' sociodemographic variables included age, gender, race/ethnicity, Pell grant eligibility, first-generation status, and gross family income. Race/ethnicity was coded into five categories: $1 = Asian$, $2 = Black/African\ Americans$, $3 = Hispanic/Latinos$, $4 = White$, and $5 = Others$. The family gross income variable included three levels: $1 = high\ income$ ($60,000 or above), $2 = middle\ income$ ($20,000 to $59,000), and $3 = low\ income$ (lower than $20,000). The other sociodemographic variables were coded dichotomously and the details are presented in Appendix.

To best reflect the transfer students' academic experiences prior to their enrollment in the UDFW, I selected two variables: (a) whether the transfer student received an associate degree, and (b) the number of transfer credit hours accepted by the UDFW. To provide a fuller understanding of the transfer students' early academic experience at the UDFW, I included variables that represent students' preparation, workload, and performance: (a) Math

preparedness, (b) English preparedness, (c) number of credit hours (excluding remedial courses) attempted in the first semester, and (d) first-semester GPA. Math and English preparedness were measured by whether transfer students successfully completed, by the end of the first semester, at least one of the college-level, foundational mathematics and English course, respectively. Both of the variables were dichotomously coded. The number of credit hours attempted and GPA received in the first-semester were treated as continuous variables (see Appendix).

Analytical Procedure

I conducted descriptive analyses to provide an overview of the community college transfer student profile and subgroups of students who received a STEM degree, a non-STEM degree, and those who did not obtain any degree. In addition, I utilized MLR to investigate the extent to which community college transfer students' sociodemographics, community college academic achievement, and first-year academic performance at the UDFW were associated with their likelihood of obtaining a degree in 10 years after the initial enrollment. As the outcome variable contains three conditions (i.e., STEM BA completers, non-STEM BA completers, and noncompleters), two discrete logistic regression models were estimated simultaneously, that is, non-STEM BA completers as opposed to STEM BA completers and noncompleters as opposed to STEM BA completers. The missing data in this study were limited (approximately 1% of the data points), but in order to maximize the sample size, I generated 10 imputed datasets and reported the pooled results.

Limitations

Prior to the discussion of the results, it is important to consider the limitations of the study. First, although I drew data from longitudinal transcript records, I focused only on one cohort of transfers who enrolled in Fall 2006 at a single institution. The results of the study may not be generalized to community college students who transferred more recently, or those who studied in other types of 4-year institutions. Second, I examined transfer students' STEM degree completion within 10 years of their initial transfer but did not consider variations of time-to-degree. When degree completion over different periods of time (i.e., 4-year graduation, 6-year graduation) are used as dependent variables, the results of the regression analyses may suggest different relationships between the independent variables and students' STEM degree attainment. Finally, the independent variables used in this study were limited to students' sociodemographic characteristics and transcript records. Although the findings provide insightful information regarding how these variables are associated with STEM degree attainment, they do not offer any new information about transfer students'

beliefs, perceptions, or educational and vocational goals and how these factors promote or hinder transfer students' STEM degree attainment.

Results

Descriptive Statistics

Sociodemographic characteristics. Overall, more than one third (39.4%) of the subjects were younger than 24 years, over half (56.7%) were females, and the majority (58.8%) were students of color (see Table 1). Almost half (46.4%) of the transfers were first-generation students, and nearly two thirds (66.1%) were eligible for the Pell grant.

When comparing STEM BA completers with non-STEM BA completers and noncompleters, the descriptive analysis findings suggest different patterns between these three subgroups of transfers. STEM BA completers had the highest percentage of students younger than 24 years of age (70.2%), followed by noncompleters (60.7%) and non-STEM BA completers (58.0%). Only slightly over one third (34.5%) of STEM BA completers were females, while almost two thirds of the non-STEM BA completers (65.3%) and more than half of the noncompleters (53.6%) were females. In terms of race/ethnicity, the descriptive analysis results indicate that a higher percentage of STEM BA completers (9.8%) were Asian when compared with the other two subgroups of transfers (5.4% and 7.2%). On the contrary, proportionally, more Black/African American and Hispanic/Latino students were found among the noncompleters and non-STEM BA completers. When compared with the STEM BA completers (41.3%), a higher proportion of non-STEM BA completers (46.0%) and noncompleters (48.2%) were identified as first-generation students. Approximately two thirds of transfers in all three subgroups were eligible for Pell grant. In terms of gross family income, half of each group were from low-income families, and proportionally, more STEM BA completers (25.2%) were from middle-income families than their counterparts (20.1% and 22.2%).

Community college academic achievement. Overall, a small proportion of the samples received an associate degree before enrolling in the UDFW and, on average, transferred 53.3 credit hours. When examining the subgroups, it was worth noting that every one in five non-STEM BA completers obtained an associate degree prior to transfer, which was as twice as high as the proportion of the other two transfer groups (11.1% and 11.8%). Similarly, the non-STEM BA completers transferred more credit hours (59.2) from community colleges to the UDFW than the other transfers (52.5 and 47.4).

First-year academic performance at the UDFW. Almost two thirds of the transfers (63.1%) enrolled full time in UDFW in their first semester. In total, 69.3% and

Table 1. Descriptive Statistics of the Sample ($N = 2,057$).

	STEM BA completers	Non-STEM BA completers	Noncompleters	All
n (%)	235 (11.4%)	($n = 927$, $p = 45.1\%$)	($n = 895$, $p = 43.5\%$)	($N = 2,057$)
Sociodemographic				
Age (under 24 years of age) (%)	70.2	58.0	60.7	60.6
Female (%)	34.5	65.3	53.6	56.7
Race/ethnicity (%)				
Asian	9.8	5.4	7.2	6.7
Black/African American	8.5	11.0	12.7	11.5
Hispanic/Latino	8.9	13.1	13.0	12.5
White	37.0	44.6	38.8	41.2
Other[a]	35.7	26.0	28.4	28.1
First generation (%)	41.3	46.0	48.2	46.4
Pell eligibility (%)	64.3	67.1	65.5	66.1
Family gross income (%)				
High ($\geq$$60,000)	24.8	29.5	27.1	27.9
Middle ($20,000–59,999)	25.2	20.1	22.2	21.6
Low ($<$20,000)	50.0	50.4	50.7	50.5
Community college				
Associate degree (%)	11.1	20.4	11.8	15.6
Number of CC SCH accepted	52.5	59.2	47.4	53.3
First semester at the UDFW				
Full-time students (%)	70.2	68.0	56.2	63.1
Math preparedness (%)	80.9	75.5	59.8	69.3
English preparedness (%)	81.3	86.8	83.1	84.6
Number of SCH attempted	11.5	11.3	10.1	10.8
First-semester GPA	2.7	2.8	1.8	2.4

Note. SCH = semester credit hours; CC= community college; STEM = science, technology, engineering, and mathematics; UDFW = university in the Dallas-Fort Worth.
[a]Other includes multiracial, Native Hawaiian/Other Pacific Islander, American Indian/Alaska Native, and race/ethnicity unspecified.

84.6% of the transfers were prepared in mathematics and English, respectively. On average, the transfers attempted 10.8 credit hours and their first semester GPA was 2.4.

The descriptive results show different patterns existing between STEM BA completers, non-STEM BA completers, and noncompleters. STEM BA completers had the highest proportion (70.2%) of full-time students during the first semester, followed by non-STEM BA completers (68.0%) and noncompleters (56.2%). A similar pattern was found for mathematics preparedness. Over 80%

of the STEM completers successfully passed at least one college-level mathematics course by the end of the first semester, while the percentage decreased to 75.5% for non-STEM completers and 59.8% noncompleters. With regard to English preparedness, non-STEM completers had the highest proportion (86.8%) passing at least one college-level English course, while the percentage of STEM BA completers was the lowest (81.3%). On average, STEM BA completers enrolled in more credit hours during the first semester than their counterparts, while non-STEM BA completers outperformed the other two groups according to their first-semester GPA.

MLR Analysis

The results of the MLR analysis are presented in Table 2. The overall model fit indices suggest that the model fits the data well. The log-likelihood value for the initial model with the intercept only decreased from 3,482.016 to 2,949.178, when all of the independent variables were included in the final model. This indicated that the ability to predict the outcome variable had improved. The corresponding chi-square value was statistically significant ($p < .001$), which indicated that there was a significant relationship between the dependent variable and the independent variables in the model. The *Nagelkerke* R^2 was .299. The overall classification rates were 69.7%. More specifically, the final model correctly classified 62.2% of STEM BA completers, 74.3% of non-STEM BA completers, and 66.7% of noncompleters.

Non-STEM BA completers versus STEM BA completers. The results of the MLR analysis indicated that, in comparison with obtaining a STEM degree, students who were 24 years of age or older had a higher likelihood of obtaining a non-STEM degree than their younger peers. In addition, female students were more likely to graduate with a non-STEM BA than a STEM BA when compared with their male counterparts. Students from high-income families (i.e., $60,000 or higher) were also more likely than those from low-income families (i.e., lower than $20,000) to graduate with a non-STEM degree. The other sociodemographic variables did not have statistically significant relationships with the likelihood of attaining a non-STEM degree.

Both of the community college variables have statistically significant and positive relationships with the likelihood of obtaining a non-STEM bachelor's degree. More specifically, in comparison with obtaining a STEM degree, transfers who received an associate degree prior to transfer and those who had more community college credit hours accepted by the UDFW were more likely to obtain a non-STEM degree.

Among the variables measuring transfer students' first-semester academic achievement at the UDFW, math and English preparedness have statistically significant relationships with transfers' likelihood of obtaining a non-STEM degree.

Table 2. Results From Multinomial Logistic Regression.

	non-STEM BA versus STEM BA			No BA versus STEM BA		
	B	Std. error	RRR	B	Std. Error	RRR
Sociodemographic						
Age (ref = Under 24)	0.439*	0.220	1.551	0.754**	0.229	2.126
Gender (ref = Male)	1.254***	0.169	3.503	0.767***	0.175	2.153
Race/ethnicity (ref = White)						
Asian	−0.187	0.205	0.829	−0.248	0.212	0.780
Black/African American	−0.383	0.305	0.682	−0.052	0.310	0.950
Hispanic/Latino	0.193	0.305	1.213	0.217	0.311	1.242
Other	0.317	0.283	1.373	0.158	0.293	1.171
First generation	−0.023	0.167	0.977	0.126	0.172	1.135
Pell eligibility	−0.064	0.199	0.938	−0.225	0.204	0.798
Family gross income (ref = low)						
High	0.579*	0.236	1.785	0.622	0.245	1.863
Middle	0.214	0.233	1.238	0.286	0.241	1.331
Community college						
Associate degree	0.453†	0.258	1.573	0.248	0.272	1.281
Number of CC SCH accepted	0.008*	0.004	1.008	−0.003	0.004	0.997
First semester at the UDFW						
Math preparedness	−0.735**	0.233	0.479	−0.999***	0.234	0.368
English preparedness	0.430†	0.261	1.537	0.877**	0.273	2.403
Number of SCH attempted	0.011	0.024	1.011	−0.074**	0.025	0.929
First-semester GPA	0.060	0.091	1.061	−0.839***	0.092	0.432

Note. *B* = Regression coefficient; Std. error = standard error; RRR = relative risk ratio; STEM = science, technology, engineering, and mathematics; UDFW = university in the Dallas-Fort Worth.
*$p < .05$. ***$p < .001$. **$p < .01$. †$p < .1$.

In other words, transfers who took at least one college-level mathematics course by the end of the first semester were more likely to obtain a STEM degree, while students who took one or more college-level English courses, on the contrary, were more likely to obtain a non-STEM degree. In terms of the number of credit hours that transfer students attempted in the first semester and their first-semester GPA, neither of them had a significant relationship with the likelihood of non-STEM degree completion.

Noncompleters Versus STEM BA Completers. As shown in Table 2, in comparison to receiving a STEM bachelor's degree, older transfers (24 years of age or older) and women were more likely to drop out without obtaining a bachelor's degree. The other demographic characteristics and community college academic

experiences were not found to be significantly associated with students' degree attainment. However, all of the four variables of early college experiences in the first semester at the UDFW had statistically significant relationships with the dependent variable. More specifically, transfers' students who took one or more college-level mathematics courses, enrolled in more credit hours, and received a higher GPA in the first semester were more likely to receive a STEM degree than no degree. On the contrary, students who took at least one college-level English course were more likely to drop out without obtaining a degree.

Discussion

In this research study, I analyzed longitudinal student transcript data from a large public research university and investigated the extent to which community college transfer students' sociodemographic characteristics, community college educational backgrounds, and early academic experiences at a 4-year university were related to STEM degree attainment. The findings of the study extend the current literature on early academic momentum and provide additional knowledge about important factors that matter to transfer students' success in pursuing a STEM degree.

Sociodemographic Characteristics

Aligned with previous research findings (e.g., Buchmann & DiPrete, 2006; Crisp et al., 2009; Peng, Wright, & Hill, 1995; Scott & Mallinckrodt, 2005; Wang, 2013), this study suggest that female students are less likely to obtain a STEM degree. Although some researchers found that women who intended to pursue a STEM degree were indeed more likely than men to graduate with a STEM degree, they also pointed out that women were less likely to enter into STEM fields (Zhang et al., 2019). Not surprisingly, this finding once again reinforces the gender gap in STEM participation and degree completion.

The study findings also suggest that, in comparison with obtaining a non-STEM degree or no degree, students who are younger than 24 years are more likely to obtain a STEM degree than their older counterparts. A plausible explanation is that older students tend to experience more life events while attending college, such as work, marriage, childbirth, or divorce (Goldrick-Rab, 2010). Consequently, adult learners may have to enroll in college part-time to balance school, career, and family, and as shown in research (e.g., Adelman, 1999, 2006; Crosta, 2014; Jacobs & King, 2002), part-time enrollment exerts a negative impact on degree completion.

Another sociodemographic variable associated with STEM degree attainment is students' family income. When compared with transfer students from low-income families, the ones from high-income families are more likely to obtain a degree in a non-STEM field than STEM. It seems that this study

finding is contradicted with previous evidence, which suggests that students from low-SES backgrounds are less likely to enter STEM nor obtain a STEM degree (Eagan et al., 2010; Zhang et al., 2019); however, these studies did not focus specifically on transfer students nor considered differences between non-STEM degree completers and those who did not at all complete a degree. Meanwhile, empirical findings suggest that family SES background has an impact on students' college and major choices (Sianou-Kyrgiou, 2010). For instance, students with a lower SES background tend to choose college and major that are more applicable to the job market when compared with their peers from higher SES families (Goyette & Mullen, 2006; Mullen, 2010). This may provide a possible explanation for the higher likelihood of low-income students graduating with a STEM degree, because the STEM degree may be perceived as more competitive in the labor market than a non-STEM one and associated with greater job security and income.

Community College Academic Achievement

The community college transfer function provides a remarkable opportunity for students who otherwise may not have access to higher education. As shown in the study, about 60% of the transfers used the community college as a stepping stone to receiving a bachelor's degree within 10 years of their initial enrollment at a 4-year university. However, only slightly over 10% of the transfers obtained a degree in STEM fields of study. This may indicate that although community colleges have great potential to promote bachelor's degree attainment, it may be a more challenging pathway for transfers interested in pursuing a STEM degree when compared with their peers in non-STEM majors. In this study, in comparison with students completing a non-STEM degree, the STEM BA completers are less likely to obtain an associate degree and tend to transfer fewer credits from a community college to the 4-year university. This finding is different from past literature. On the contrary, early research suggests a positive relationship between baccalaureate degree completion and the associate degree attainment (i.e., Crook et al., 2012; Ehrenberg & Smith, 2004; Kopko & Crosta, 2016), and the number of community college credits accepted by the 4-year university (i.e., Doyle, 2006; Monaghan & Attewell, 2015). However, these studies did not consider the differences between STEM and non-STEM disciplines. The study findings may suggest that community college transfers who intend to pursue a STEM degree transferred earlier than their non-STEM peers and thus, they accumulated fewer credit hours. The findings may also imply that the transfer requirement for students pursuing STEM and non-STEM majors is different. STEM programs in the 4-year university may require students to take more courses at the 4-year level and allow fewer courses taken previously to be accepted by the institution.

Early Academic Experiences at 4-Year Institutions

The study findings demonstrate that early academic experiences post transfer are important for students' degree attainment. When compared with non-STEM degree completers and students who did not receive a bachelor's degree, taking at least one college-level mathematics course in the first semester has a positive relationship with STEM degree attainment. This finding echoes previous research that highlights the importance of mathematics preparation and its positive impact on persistence and degree attainment in STEM fields of study (e.g., Chen & Soldner, 2013; Shaw & Barbuti, 2010; Tyson et al., 2007; Zhang et al., 2019). Taking college-level English courses, on the other hand, has a negative association with STEM degree attainment. This finding could be simply attributed to the different requirements of STEM and non-STEM degree programs, but it may also underline the importance of the timing of taking mathematics courses. For transfers pursuing a STEM degree, in comparison to English courses, taking math courses early on plays a more critical role in their degree completion, since many of the foundational math courses serve as "gatekeeper courses" and students must pass them to continue and succeed in a STEM major. Therefore, in terms of STEM degree attainment, the time at which transfer students take the mathematics courses could be equally as important as their performance in these courses.

In addition, the number of credit hours that transfer students attempted during the first semester and their first-semester GPA were found to be significantly associated with the likelihood of obtaining a STEM degree. However, these variables are only significant when STEM degree attainment is compared with no degree completion. In other words, transfers who enrolled in more credit hours and had higher GPAs in the first semester are more likely to graduate with a STEM degree than obtaining no degree. The findings suggest that both quantity (i.e., number of credit hours attempted) and quality (i.e., GPA) of early college experiences are critical for transfer students' STEM degree attainment. The findings are consistent with early studies focusing on the importance of academic momentum on desired educational outcomes (Tyson et al., 2007; Wang, 2013).

Implications and Conclusion

The findings of this study provide implications worth noting for policy and practice to strengthen the community college pathway to STEM degree attainment. First of all, the study findings point to gaps in STEM degree completion by student sociodemographic characteristics (i.e., gender, age, and family income). Not surprisingly, this study suggests that female and older students are less likely to obtain a STEM degree. To improve female transfer students' intention to pursue and persistence in a STEM program, it requires continued

effort and support from both 2- and 4-year institutions. Understanding the underlying factors that promote or hinder female students' interests in and intent to pursuing a STEM degree is a critical first step to bridge the gender gap in STEM education. Research demonstrates that women are more likely than men to perceive lack of fit or have low attainment values about STEM (Heyman, Martyna, & Bhatia, 2002; Matusovich, Streveler, & Miller, 2010). As such, community colleges could engage female students, as soon as they enroll in community college, in conversations about values and career opportunities of various STEM disciplines. With more knowledge and deeper understanding of specific STEM majors and future career possibilities, female students may develop a stronger interest in STEM and become more motivated to transfer and to persist in a STEM degree program. Equally important is to understand female transfers' educational experiences at both 2- and 4-year institutions and barriers that they often encounter while pursuing a STEM degree. For example, past literature has shown that women withdrawing from STEM is largely due to their experiences in the unwelcoming environment in STEM programs (Rypisi, Malcom, & Kim, 2009). Therefore, it is important for both 2- and 4-year institutions to develop a learning environment that does not reemphasize on gender stereotypes, but rather, boost women transfer students' confidence in pursuing a STEM degree and nurtures their sense of belonging in a STEM program.

Likewise, for older transfer students, before effectively implementing any practices and policies to enhance their STEM success, colleges and universities need to gain a thorough understanding of the older transfers' perspectives and factors contributing to their STEM completion or incompletion. Although adult learners tend to have clearer career goals and a higher level of motivation to complete a degree than their younger peers (Aslanian, 2001), they are more likely to encounter greater challenges in balancing work, family, and study (Zhang, Lui, & Hagedorn, 2013). Thus, to better facilitate these students, both community colleges and 4-year universities could develop programs and practices that best address the specific needs of these students, such as workshops for job interviews, one-on-one consultation on resume development, and on-campus or local daycare resources. Meanwhile, to maximize adult learners' participation in these programs, institutions should consider offering programs beyond regular office hours or incorporate online resources, because due to work responsibilities and family obligations, older transfers may not be available to participate during regular hours (Allen & Zhang, 2016).

It is noteworthy that low-income transfers, when compared with transfers from high-income families, have a higher likelihood of obtaining a STEM degree than a non-STEM degree. To fully understand factors accounted for low-income transfers' STEM degree attainment, in addition to students' transcript records and demographic backgrounds, it is important for higher education researchers, educators, and administrators to investigate low-income students' individual perceptions, goals, and beliefs about degree attainment

and STEM career opportunities. It is also important for colleges and universities to gain a fuller understanding of low-income students' educational and vocational goals and how they drive them to pursue a STEM major and graduate with a STEM degree.

As discussed earlier, transfers who received a STEM degree are less likely than those who obtained a non-STEM degree to complete an associate degree and tend to transfer fewer community college credit hours to the 4-year university. The study findings imply that community colleges, as an important pathway to bachelor's degree attainment, are probably utilized by STEM and non-STEM transfers in different capacities. To better assist the community college transfer process, advisors at community colleges need to understand different paths that transfer students intend to take and requirements specific to the discipline that the students choose to pursue. Thus, advisors can provide students with accurate information and resources to facilitate their goal achievement. As indicated by numerous researchers (e.g., Bahr, 2008; Packard & Jeffers, 2013; Zhang & Ozuna, 2015), quality advising plays a pivotal role in the transfer process and student success, especially for STEM students who tend to navigate more restricted and precise course sequences. Therefore, despite resource constraints, community colleges should equip academic and transfer advisors with the most up-to-date knowledge about prerequisites and differences in 4-year program requirements. Advisors could also employ helpful strategies to illustrate the complex process to the STEM transfer students. For instance, advisors can incorporate both written and web-based resources in advising and use visual tools to better depict the course sequences (Bahr, Jackson, McNaughtan, Oster, & Gross, 2017). A smooth transition from a community college to STEM programs in 4-year universities also requires state-level support and planning. An effective statewide articulation policy could lessen the challenges to transfer, minimize the loss of transfer credits, and ultimately, promote students' timely degree attainment (Stern, 2016). Therefore, articulation policy should be developed and strengthened at the state level to improve collaboration between 2- and 4-year institutions and to eliminate unnecessary duplication of courses.

This result may also provide implications for future studies on transfer students with a particular emphasis on the Texas context. House Bill 9, which is also known as the Higher Educational Outcomes-Based Funding Act, was passed in 2011 and a new performance model for funding community colleges in Texas was adopted in 2013 (The Texas Higher Education Coordinating Board, 2018). This model defines multiple Student Success Points (e.g., completing college-level math, earning 30 credit hours, receiving an associate degree) and, according to the importance of the accomplishments, these Success Points are assigned with different weight (e.g., .5 point for college-level reading, 1 point completing 15 credit hours, 2.25 points receiving a certificate or an associate degree in STEM). The State funding is then appropriated based on the number

of Student Success Points that community colleges received. Although the sample in this study transferred prior to the implementation of this funding model, the result may indicate that transfer students pursuing a STEM degree can exert different impact on community colleges' funding opportunities as they are less likely to receive an associate degree than their non-STEM peers. This result may also encourage future researchers to study community college students who transferred after the implementation of this performance-based funding policy and examine the impact of transfer students' pursuit of different degree programs (STEM vs. non-STEM) on community college funding and transfer policies.

Finally, this study highlights the importance of early academic experiences at the 4-year university, including mathematics and English preparedness, the number of credit hours attempted during the first semester, and the first-semester GPA. Research has shown that inadequate math preparation posts important barrier to community college students in STEM programs (Hagedorn & DuBray, 2010) and students who do not perform well in the early mathematics courses are more likely to discontinue their STEM pursuit and even withdraw from college (Seymour, 2001; Seymour & Hewitt, 1997). On the contrary, success in early math courses was found to be an important predictor of success in STEM (Gardner, Pyke, Belcheir, & Schrader, 2007) and can increase students' academic confidence to succeed in their future college endeavor (Ellington, 2006). Therefore, improving transfer students' early mathematics experiences and performance is a critical step leading to a higher success rate in STEM persistence and graduation. To achieve this goal, as suggested by empirical evidence (Romney, 2011), colleges and universities could improve students' engagement in their first-year mathematics classes by incorporating technology. Furthermore, colleges and universities could offer learning opportunities for faculty and graduate teaching assistants who directly interact with transfer students in the "gatekeeper courses" to keep themselves abreast with the most current pedagogical methods and to learn from student affairs professionals about difficulties that transfer students often encounter on 4-year campuses. Other practices that institutions should consider adopting to benefit transfer students' mathematics learning include better aligning 2- and 4-year math curriculum, offering peer-tutoring, and developing learning communities for transfers. Instead of implementing practices in isolation, 4-year universities should develop a comprehensive strategy that incorporates a combination of practices to improve transfer students' engagement in first-year mathematics courses.

The findings regarding the positive association between the number of credit hours attempted and GPA and transfers' STEM degree attainment emphasize the importance of early academic load and performance in STEM degree completion. This is especially critical for transfer students, as ample evidence (e.g., Hill, 1965; Starobin & Laanan, 2008; Townsend, 1995; Townsend &

Wilson, 2006) has indicated that transfer students are more likely than their peers who begin directly at 4-year universities to experience academic challenges, such as a decline in GPA in their first semester, or "transfer shock." The challenges could be even more severe for STEM transfers, given the rigor and selectivity in most STEM programs in 4-year universities (Wyner et al., 2016). In addition, transfer students are facing challenges while adjusting themselves to a new learning environment, different academic expectations and requirements, and for some, isolation from family and friends (Laanan, 2007; Rhine, Milligan, & Nelson, 2000). Dealing with both academic and social stress that can result in attrition and degree incompletion, it can be extremely challenging for transfer students to maintain competitive in STEM programs. As such, these students may need additional support and resources to keep up with the rigorous standards of the STEM programs. In addition to the strategies discussed earlier, 4-year universities could develop additional tutoring sessions for transfer students in STEM disciplines, incorporate online advising sessions into face-to-face meetings with advisors, and offer more flexible course schedules (i.e., during evenings or Saturdays) to better accommodate transfer students' schedules, enhance their adjustment, and ultimately, improve their persistence and graduation rates in STEM degree programs.

In summary, focusing on community college transfer students who obtained a bachelor's degree in a STEM field of study, this research extends the current understanding of early academic momentum for STEM success. The findings of the study also provide new knowledge that higher education researchers, practitioners, administrators, and policymakers could use to improve the community college-to-university transfer process to enhance the bachelor's degree production, especially for students who are interested in pursuing STEM. Future research on transfer students and their early academic momentum experiences should be conducted to enhance the community college pathway to STEM degree completion. It would be more informative to include transfer students' individual-level variables, such as their perceptions about STEM careers, educational and vocational goals, and self-efficacy on mathematics and science. As such, the findings of the studies could provide a fuller understanding of transfer students' personal factors that drive them to pursue or leave STEM. Second, instead of using data from a single institution, future researchers could draw information from nationally representative datasets, so the results can be generalized to a broader transfer student population. In addition, focusing on specific transfer student subpopulations such as female, older adults, and low-income students, future researchers could offer more meaningful knowledge on factors that particularly promote STEM success within each of the transfer student groups, and thus targeted strategies and programs can be developed on both 2- and 4-year campuses to better facilitate transfer students' learning and improve their STEM degree completion.

Appendix

Variable Names, Description, and Coding.

Variable name	Description	Coding
Independent variables		
Age	Age when first enrolled in the UDFW	0 = Under 24, 1 = 24 and older
Gender	Gender of the transfer	0 = Male, 1 = Female
Race/ethnicity	Race/ethnicity of the transfer	1 = Asian, 2 = Black/African Americans, 3 = Hispanic/Latinos, 4 = White, and 5 = Others (multiracial, Native Hawaiian/ Other Pacific Islander, American Indian/ Alaska Native, and race/ethnicity unspecified). Reference group = White
First generation	Whether the transfer is a first-generation college student	0 = No, 1 = Yes
Pell eligibility	Whether the transfer is eligible for Pell grant	0 = No, 1 = Yes
Family gross income	The transfer's family gross income when first enrolled in the UDFW	1 = High income ($60,000 or above), 2 = Middle income ($20,000 to $59,000), and 3 = Low income (lower than $20,000). Reference group = low income
Associate degree	Whether the transfer obtained an associate degree prior to transfer	0 = No, 1 = Yes
Number of CC SCH accepted	The number of semester credit hours earned at the previous community college that were accepted by the UDFW	Actual number

(continued)

Continued

Variable name	Description	Coding
Math preparedness	Whether the transfer successfully passed at least one college-level mathematics course by the end of the first semester at the UDFW	0 = No, 1 = Yes
English preparedness	Whether the transfer successfully passed at least one college-level English course by the end of the first semester at the UDFW	0 = No, 1 = Yes
Number of SCH Attempted	The number of semester credit hours that the transfer attempted during the first semester at the UDFW	actual number
First-semester GPA	GPA by the end of the first semester at the UDFW	actual GPA (between 0.00 and 4.00)
Dependent variable		
Baccalaureate degree completion	Whether the transfer received a bachelor's degree and whether it was in a STEM field of study by the Summer of 2016	1 = Obtained a STEM bachelor's degree, 2 = Obtained a non-STEM bachelor's degree, 3 = Did not obtain a bachelor's degree

Note. CC= comunity college; GPA = grade point average; SCH = semester credit hours; STEM = science, technology, engineering, and mathematics; UDFW = university in the Dallas-Fort Worth.

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