STEM Persisters, Switchers, and Leavers: Factors Associated with 6-Year Degree Attainment for STEM Aspiring Community College Transfer Students

Science, technology, engineering, and mathematics (STEM) fields play vital roles in the U.S. economy and its competitiveness of scientific and technological innovation worldwide (Chen, 2015; National Science Council, 2008). While it has been a priority for the nation to produce a sufficient number of postsecondary graduates qualified for STEM professions, there are rising concerns about the U.S.'s ability to develop and retain talent in STEM fields. A critical issue is that students who start higher education studies in these fields do not complete their degrees (President's Council of Advisors on Science and Technology, 2012). When compared with the other nations, statistics suggest that U.S. is lagging behind the other nations in STEM preparation. According to the latest Science and Engineering Indicators 2020 (National Science Board, 2020), U.S. is one of the countries that have the lowest proportions of STEM baccalaureate degrees awarded (excluding social/behavioral sciences) among over 50 countries or regions in the report.

The concerns about STEM education in the U.S. have been directed towards the need to increase the quantity, quality, and diversity of students in programs and careers in STEM fields (e.g., National Academy of Science, Engineering, and Medicine, 2016; National Governors Association, 2007, National Research Council, 2012). While it is important to encourage more students to pursue STEM degrees, it is equally important, if not more, to reduce students' attrition from STEM fields. However, many STEM entrants departed from their original programs by either changing majors to non-STEM fields or leaving college entirely without earning a degree. National data have shown that, among students who entered STEM fields between 2003 and 2009, almost half (48%) of the bachelor's degree students and more than two-

thirds (69%) of the associate degree students had left STEM by Spring 2009 (Chen, 2013). The National Science Board (2018) indicated that over a quarter (26.7%) of students who enrolled in natural sciences and engineering majors switched to social and behavioral sciences or other non-STEM majors within two years (p. 53).

The attrition issue is even more severe for community college transfer students who intend to pursue a STEM degree. Community colleges have become an important pathway to STEM education for students interested in earning a STEM degree but could not afford a traditional 4-year university program (Hagedorn & Purnamasari, 2012). Indeed, nearly half (47%) of the science and engineering bachelor's degrees were awarded to students who took courses at a community college sometime during their educational trajectory (National Science Board, 2020). Although community colleges have increasingly become a critical player in improving the production of STEM graduates, research consistently suggests that STEM entrants who began higher education at community colleges have a lower chance of earning a STEM degree than their counterparts who have never transferred. For instance, evidence has shown that community college transfer students are more likely than 4-year students to switch to non-STEM majors (NASEM, 2016; Tyson, 2011) and less likely to obtain a STEM baccalaureate degree (Wang, 2015). When students depart from STEM degree programs, it counters society's efforts to recruit more talent to the STEM fields. It also leads students to a higher amount of debt since many would need to take additional courses to graduate (NASEM, 2016). Indeed, researchers suggest it would increase the cost-efficiency and substantiality of the STEM workforce if STEM attrition could be reduced by even a small percentage (Ehrenberg, 2010; PCAST, 2012). Thus, an examination of factors that could reduce STEM attrition of community college transfers is warranted.

Therefore, this study intended to deepen the current understanding of STEM persistence and attrition by examining the extent to which factors unique to transfer students are related to the likelihood of completing a STEM degree within six years. This study tracked multiple cohorts of STEM aspiring transfer students matriculated at a public 4-year research university in North Texas between Fall 2007 and Fall 2014, and addressed the following research questions:

1. Among the community college transfer students who declared a STEM major at their initial transfer, what are the characteristics of those who graduate with a STEM degree (STEM persisters), those who graduate with a non-STEM degree (STEM switchers), and those who did not receive any degree by the end of the sixth year (STEM leavers)?
2. For these transfer students, to what extent are their sociodemographic characteristics, community college educational experience, and first-semester academic performance at the 4-year university related to their likelihood of obtaining a STEM degree?

Review of Relevant Literature

This section presents an overview of the study context by reviewing the current literature on STEM persistence and attrition. Specifically, the literature review provides a synthesis of research studies focusing on STEM attrition, characteristics of STEM dropouts, and factors contributing to student persistence in or departure from STEM fields. Due to the limited research on the transfer student population, I extended the review of STEM attrition literature to studies targeting other student populations, such as students who begin higher education at 4-year universities and community college students who do not transfer.

Sociodemographic Characteristics

A rich body of literature has consistently suggested that certain sociodemographic characteristics are associated with higher STEM attrition rates, such as female, traditionally

underrepresented racial/ethnic minorities, and first-generation status (e.g., Anderson & Kim, 2006; Eagan, Hurtado, & Chang, 2010; Griffith, 2010; Hill, Corbet, & Rose, 2010; Kokkelenberg & Sinha, 2010; Shaw & Barbuti, 2010). For instance, Gayles and Ampaw (2014) found that women had a lower chance than men of completing a STEM baccalaureate degree within six years. Bahr et al. (2017) found that more female students took the lowest-skill courses in STEM, which led them to a higher attrition rate from STEM than their male counterparts. Chen (2015) also noticed that female students were more likely than males to switch from STEM to non-STEM majors. However, Tyson (2011) found no effects of gender on engineering degree attainment. He further discussed that the gender gap in degree attainment "largely results from studies that use samples of students who intended to major in a STEM field rather than actual STEM majors" (p. 774). In addition, Zhang et al. (2019) pointed out that female students had a lower probability than men to declare a STEM major, but those who entered STEM were more likely than men to obtain a STEM degree.

Research also shows that the STEM leaking pipeline may be more pronounced for some racial/ethnic groups. Flynn (2016) reported that Black and Hispanic students had a higher risk of dropping out of STEM, although they were entering STEM programs at similar rates with White or Asian Americans (Moakler & Kim, 2014), Meanwhile, evidence consistently suggests that Asian Americans have a higher likelihood to persist in STEM programs and graduate with a STEM degree (e.g., Crisp et al., 2009; Zhang et al., 2019).

In addition, low socioeconomic (SES) backgrounds negatively affect STEM persistence and degree completion (Eagan, Hurtado, & Chang, 2010; Zhang et al., 2019). In fact, financial concerns were one of the major reasons that led to students' departure from STEM (Eagan et al., 2010; Packard et al., 2011). Ferrare and Lee (2014) investigated STEM switchers and found that

they were more likely to have low SES backgrounds and in need of more financial support. Interestingly, Chen (2013) found that STEM entrants from low SES families were less likely to switch to non-STEM majors than their peers from high SES families. Zhang (2019) reported a similar finding that transfer students with a family annual gross income of $60,000 or above had a higher risk of switching to non-STEM programs than their counterparts with a lower family income.

Precollege Academic Preparation

Weak academic preparation has been consistently reported to be associated with STEM attrition (e.g., Griffith, 2010; Méndez, Buskirk, Lohr, & Haag, 2008; Whalen & Shelley, 2010). Ample evidence has shown that students who receive lower high school GPAs and SAT scores are more likely to leave STEM when compared with their peers who have higher scores (Espinosa, 2011; Griffith, 2010; Méndez et al., 2008).

In addition to considering high school variables, researchers investigated students' previous college experiences if they attended other higher education institutions after graduating from high school. For example, for community college transfer students, researchers (Crook, Chellman, & Holodet, 2012; Ehrenberg & Smith, 2004) found that associate degree attainment was positively associated with baccalaureate degree completion. In addition, researchers (Doyle, 2006; Monaghan & Attwell, 2015) examined the impact of community college credit hours on transfer students' bachelor's degree attainment, and found that students who had a higher number of community college credits accepted by 4-year universities were more likely to persist after transfer and to earn a bachelor's degree. When examining degree attainment in STEM in particular, however, Zhang (2019) found that students who earned an associate degree prior to transfer and those who transferred more credit hours were more likely to obtain a non-STEM

degree than a STEM degree.

Early Academic Performance in College

In the literature on 4-year degree completion, researchers recognized the importance of students' early academic performance in college. Students who do not earn a sufficient number of credits in STEM courses and those with a lower academic performance during the first year in college are facing greater challenges of persisting in STEM programs. For instance, Chen (2013, 2015) found that, during the first year, STEM aspirants who had fewer STEM credit hours and lower STEM grades were more likely to switch to non-STEM majors. Similarly, Méndez et al. (2008) indicated that the number of STEM courses taken and GPA earned in the freshmen year had a positive association with students' STEM persistence. First-semester GPA is also positively associated with STEM persistence and graduation (Crisp et al., 2009; Dika & D'Amico, 2016).

Mathematics preparation and performance is extremely critical for student persistence and degree completion in STEM. Students who lack adequate preparation in mathematics tend to leave STEM programs in college (e.g., Chan & Wang, 2018; Mattern, Radunzel, & Westrick, 2015). Students who did not perform well in the gateway mathematics courses could be viewed as incapable of succeeding in STEM fields and consequently depart from STEM programs. For instance, engineering majors who received a C average or lower in Calculus had a higher risk of leaving the program (Veenstra, Dey, & Herrin, 2009). The level of mathematics courses also impacts STEM attrition. Students who took precollege or introductory mathematics courses during their first year in college were more likely to switch to non-STEM majors than their peers who took advanced math courses (Chen, 2013).

Studying community college transfer students pursuing an engineering degree,

researchers (Laugerman, Shelley, Rover, & Mickelson, 2015) found that students' retention and graduation were positively related to grades of B or higher in Calculus and C or higher in Physics, which is a Calculus-based course. In another study focusing on transfer students, Zhang (2019) found that students who took college-level mathematics courses during the first semester had a higher chance of obtaining a STEM degree than those who did not. Also, students who attempted fewer credit hours and those who earned lower GPAs in the first semester had a higher risk of obtaining no degree than earning a STEM degree (Zhang, 2019).

Methods

Research Site and Study Sample

I used undergraduate student transcript data collected from community college students who enrolled in a STEM degree program at their initial transfer to a public research university in North Texas (thereafter NTU). NTU has been recognized for its diverse student population, the high proportion of transfer students, and the competitiveness of STEM programs in the region.

The study sample included community college transfers who matriculated to NTU in the Spring or Fall semesters between Fall 2007 and Fall 2014. Students who began in Summer semesters were excluded because their first-semester enrollment pattern tends to be different from those who started in the Fall or Spring semesters, as they often enroll part-time and take fewer courses in the summer. If these students were included, this study could introduce biases when examining the impact of students' first-semester academic experience on degree attainment.

The community college transfer status was defined by the last institution the students enrolled prior to NTU. If a student attended a community college immediately before NTU, then the student was identified as a community college transfer student. To investigate factors

contributing to STEM attrition, only STEM aspirants, or transfer students who claimed a STEM major as they entered NTU were included in the sample. Specifically, STEM majors in this study included architecture, engineering, computer and information sciences, mathematics and statistics, and natural sciences. Behavioral and social sciences, such as psychology, economics, sociology, and political sciences, were coded as non-STEM majors. In total, the sample contained 6,159 community college transfer students who declared a STEM major when they first transferred to NTU between Fall 2007 and Fall 2014.

Variables and Measurements

The dataset was built on a wide array of academic records drawn from longitudinal transcripts of the study sample, including enrollments, course attempted and failed, credits attempted and earned, grades, graduation, and degree intended and received. It also contained transcript data from the previous community college, including types of courses taken, the number of credits transferred to NTU, and whether an associate degree was obtained prior to transfer. Additionally, the dataset consisted of students' sociodemographic information such as gender, age, race/ethnicity, Pell grant eligibility, gross family income.

Dependent variable. The dependent variable used in the multinomial logistic regression (MLR) model is the 6-year degree attainment status of the STEM aspiring transfer students. This variable describes whether the transfer students who initially enrolled in a STEM degree program graduated with a degree within six years. The transfers were classified into three subgroups, including 1) *STEM persisters*, who graduated with a STEM degree within six years, 2) *STEM switchers*, who graduated with a non-STEM degree within six years, and 3) *STEM leavers*, who did not earn any degree within six years.

Independent variables. Guided by the previous literature, I employed variables

focusing on the following areas: students' sociodemographic characteristics, academic achievement in community college, and early academic performance during the first semester at NTU. The sociodemographic variables included students' age (actual number), gender (male or female), race/ethnicity (Asian, Black/African American, Hispanic/Latinos, White, or Others), Pell grant eligibility (yes or no), first-generation status (yes or no), and annual family gross income (low, middle, or high). Family income lower than $20,000 per year was coded as low, income between $20,000 and $59,999 was categorized as middle, and income $60,000 or higher was classified as high.

Community college academic achievement was indicated by the number of transfer courses accepted by NTU, and whether the student earned an associate degree prior to transfer. Early academic performance at NTU was measured by students' number of courses attempted, whether the student withdrew any courses, first-semester GPA (between 0 and 4.0), and the most advanced mathematics courses completed during the first semester (Levels 1, 2, or 3). Mathematics courses were classified based on the level of difficulties. Students who did not take any mathematics courses or took only precollege mathematics were coded as Level 1, those who took introductory mathematics as Level 2, and those who took calculus I or more advanced courses as Level 3.

Data Analysis

I first employed descriptive statistics to present the overall characteristics of the transfer students in the sample and the subgroups – STEM persisters, switchers, and leavers. I then conducted multinomial logistic regression analysis to examine the extent to which students' sociodemographic characteristics and students' early academic achievement in both community colleges and NTU were associated with their likelihood of obtaining a STEM degree within six

years after transfer.

Limitations

This study has three major limitations, which should be addressed before the discussion of results. First, I used data drawn from community college students who transferred to NTU in 15 different semesters over eight years. However, changes across the different cohorts were not measured nor analyzed in the study. For instance, students who transferred to NTU in Fall 2007 may have had different experiences compared to those who transferred five years later. Second, this study only examined whether students departed from their original STEM degree programs by the end of the sixth year, but did not investigate when they departed. As such, faculty and student affairs professionals may not be capable of identifying the most critical time for offering prevention and intervention programs to reduce STEM attrition rates. Third, although this study incorporated a wide spectrum of variables to capture transfer students' characteristics and their academic experiences pre- and post-transfer, students' attitudes, beliefs, perceptions about STEM majors and careers were not analyzed in this study due to data unavailability.

Results

Descriptive Statistics

The results of the descriptive analysis provide an overview of the sample and show differences and similarities between the STEM persisters (i.e., earned a STEM degree within six years), switchers (i.e., earned a non-STEM degree within six years), and leavers (i.e., did not earn any degree in six years).

Sociodemographic characteristics. The overall average age for the sample was about 24 years old, and among them, the persisters and switchers tended to be younger than the leavers (see Table 1). More than 70% of the persisters (70.6%) and switchers (74.0%) were identified as

24 years of age or younger, while only about two-thirds of the leavers were found in the same age group. In terms of gender, a little over one-third (34.5%) of the sample were female. When examining the gender distribution in each of the three subgroups, female students accounted for only one-third of the persisters (33.1%) and leavers (33.3%), while they made up almost half (43.1%) of the switchers. Overall, the largest racial/ethnic group of the sample was White (43.6%), followed by Hispanic/Latino (24.1%), Asian (15.1%), and Black (11.7%). When compared to switchers and leavers, Asian students (19.8%) in the persisters were overrepresented, while Black (8.1%) and Hispanic students (23.0%) were underrepresented. Nearly half (48.3%) of the sample were identified as first-generation students (48.3%), and among the three subgroups, the leavers had the largest proportion. Almost every one in two (49.0%) students in the sample were eligible for the Pell grant and the proportions were approximately the same across all three subgroups. Of the sample, slightly less than half (47.1%) were from families with an annual gross income lower than $20,000 (low). Approximately one-fourth (24.4%) had a family income between $20,000 and $59,000 (middle), and the others' family income was higher than $60,000 (high). Among the three subgroups of transfers, the leavers had the largest proportion of students from a low family income background and, in contrast, the smallest proportion with a high family income.

[Insert Table 1 About Here]

Community college background. Overall, nearly one-fifth (17.5%) of the sample received an associate degree before they transferred to NTU. When compared with persisters and switchers, proportionally, fewer leavers earned an associate degree. On average, the STEM aspirants in the sample transferred approximately 20 courses to the university, with persisters having the highest number (22.4) of courses and the leavers the lowest (18.8).

First-semester academic performance. During the first semester at NTU, students in the sample received a GPA of 2.5, and enrolled in 3.7 courses. The differences between the three subgroups were apparent: persisters, on average, had the highest GPA (2.7) and the leavers had the lowest (1.7). Similarly, the persisters enrolled in the most courses (4.0) and the leavers in the least (3.5). Overall, more than a quarter (27.7%) of the students in the sample dropped at least one course during the first semester. Among the subgroups, one-third of the leavers (33.3%) withdrew one course or more during the first semester, while less than one-fifth (19.3%) of the persisters did so.

The majority (73.4%) of the students in the sample were at Level 1 math, which indicated they did not take any college-level mathematics during the first semester. The highest percentage of Level 1 math completers were found in leavers (80.1%), followed by switchers (69.9%) and persisters (65.1%). However, in contrast, persisters had the highest percentage (23.0%) of students achieved Level 3, which was almost four times as high as the leavers (6.6%).

Multinomial Logistic Regression Analysis

The overall model fit indices suggest that the final MLR model fits the data well. The log-likelihood value for the initial model with the intercept decreased from 11761.22 to 9691.32 in the final model, which means that the final model has a better ability to predict the outcome variable. The corresponding chi-square value is statistically significant ($p < 0.001$), which indicates that there is a significant relationship between the dependent variable and the independent variables in the model. The *Nagelkerke* R^2 was .338.

[Insert Table 2 About Here]

STEM switchers vs. STEM persisters. As shown in Table 2, older STEM aspiring transfer students were more likely than their younger peers to become STEM switchers than

persisters. When compared with males, female transfers were more likely to be identified as switchers. Asians were more likely than White students to be persisters than switchers.

STEM aspirants who transferred more courses to NTU had higher chances of persisting in STEM programs and obtaining a degree within six years, while earning an associate degree was not significantly associated with the likelihood of obtaining a STEM degree. The results also indicated that the transfer students' academic performance during the first semester at NTU was significantly related to their 6-year degree attainment in STEM. More specifically, transfer students who took more courses without any withdrawals were more likely to be persisters than switchers. Similarly, students who received a better GPA had a higher likelihood of being persisters. Transfers who took calculus I or more advanced mathematics courses (Level 3) during the first semester were more likely to be persisters than switchers when compared to those who took precollege-level (Level 1) or introductory mathematics (Level 2).

STEM leavers vs. STEM persisters. The MLR results indicated that older learners, first-generation students, and students with a lower family income had higher risks of becoming STEM leavers. When compared to White students, Asians were likely to be persisters than leavers.

The results suggested that students who had fewer transfer courses accepted at NTU had higher risks of becoming leavers. While earning an associate degree did not have a significant association with STEM degree attainment, early academic achievement at NTU was significantly related to the likelihood of being a STEM persister. In other words, transfer students who enrolled in more courses, those who did not withdraw any courses, and those who received a higher GPA were more likely to be persisters than leavers. In addition, students who took a higher level of mathematics courses (Level 3) in the first semester were more likely to be

persisters than leavers.

Discussion and Implications

Tracking community college students who declared a STEM major at their initial transfer and examining their degree attainment within six years after transfer, this study offers several meaningful findings that particularly speak to community college transfer students' experiences. In the following section, this study highlights the main findings, discusses implications for practice and policy to reduce STEM attrition, and provides suggestions for future research on transfer students' STEM persistence and success.

Sociodemographic Characteristics

Age. The results suggest that, when compared to earning a STEM degree, older transfers are more likely than their younger peers to switch to a non-STEM degree or receive no degree. This may indicate that older transfers experience more substantial challenges while navigating the 4-year environment, although they demonstrated an equal interest in STEM as their younger peers when they first transferred. A possible explanation is that older learners may struggle to commit themselves to academic studies at the same level as the younger transfers, because they are often distracted by life events while pursuing a degree (e.g., marriage, childbirth, divorce) (Goldrick-Rab, 2010). As such, these students experience more challenges in maintaining a balance between work, family, and school (Zhang, Lui, & Hagedorn, 2013). For instance, Maltese and Tai (2011) found that having parental obligations while completing a degree had decreased the chances of obtaining a STEM degree. Meanwhile, the rigor of STEM programs may require a higher level of commitment than other disciplines and demand more time and effort from the students. When the older students experience difficulties balancing academic study and other responsibilities, their interests to pursue a STEM degree may be lowered,

satisfaction with the program could be reduced, and consequently, their performance in STEM could be negatively impacted. It is not surprising that older students are more likely to leave STEM when they have poor performance (Barr, Gonzalez & Wanat, 2008; Ost, 2010; Rask, 2010; Seymour, 2001; Seymour & Hewitt, 1997).

To encourage older learners to persist in STEM majors, community colleges and 4-year universities could provide them with additional resources and tools to reduce the tension between study and non-academic responsibilities, such as workshops on improving time-management skills, one-on-one consultation on developing resumes and cover letters, online advising and tutoring sessions, and resources for on-campus and local daycare centers. In addition, these services should be offered not only during regular office hours, but also in the evenings and weekends, as the older learners may need to access these services outside the regular hours (Allen & Zhang, 2016).

Gender. Although the study finding does not suggest that female students are more likely to receive no degree, it indicates that, when compared with their male counterparts, females have a higher likelihood of switching to non-STEM programs than persisting in STEM fields. This finding supports evidence from many previous research studies (Crisp et al., 2009; Eagan et al., 2010; Shaw & Barbuti, 2010). This may not seem to be a severe concern for some, because female students who leave STEM still tend to receive a bachelor's degree. However, it may imply that STEM fields are missing these talented women who could have made an important contribution to the STEM fields if they persisted. These female students could add greater diverse perspectives in scientific research and application, and improve the rigor and completeness of scientific solutions. Certainly, female students who begin in STEM should be allowed, and indeed encouraged, to switch to a non-STEM field, if it is a major that they are

passionate to pursue. However, as indicated in the literature, such a decision can be largely affected by gender stereotypes (i.e., girls are less proficient in math) or a chilly learning environment in STEM programs (Ceci, Williams, & Barnett, 2009; Rypisi, Malcom, & Kim, 2009). Thus, both 2- and 4-year institutions should employ strategies and policies that promote gender equity in STEM classrooms and strengthen a gender-inclusive learning environment. This will benefit not only female students but also students who identify themselves beyond the binary gender norms.

Race/ethnicity. Echoing previous literature (e.g., Crisp et al., 2009; Eagan et al., 2010; Kokkelenberg & Sinha, 2010; Zhang et al., 2019), the study findings suggest that Asian students are more likely than their White peers to earn a STEM degree by the end of the sixth year of their initial transfer. According to the literature, plausible explanations include that Asian Americans express interests in STEM at an early age (Hilton & Lee, 1988), are better academically prepared in high school (Tyson et al., 2007), and have a higher motivation to study STEM (Li, Swaminathan, & Tang, 2009). Another factor that may contribute to Asian Americans' low attrition in STEM is high academic expectations from their parents (Li et al., 2009).

Similar findings have been repeatedly reported by research examining academic outcomes when race/ethnicity was used as a variable (e.g., Chang, Eagan, Lin, & Hurtado, 2011; Crisp et al., 2009; Zhang et al., 2019). If applied without caution, however, research findings like this could result in reinforcing the stereotype for Asian Americans and other racial/ethnic groups. Asian Americans have often been seen as the model minority and stereotyped as "universally academically and occupationally successful" (Museus & Park, 2015, p.563), although there is a wide range of culturally diverse subgroups within this population (Patel, 2010). This model minority idea does not explain the underpinning factors that contribute to Asian Americans'

academic achievements; instead, it disguises the struggles that they face and ignore the support that they need (Museus & Kiang, 2009). Therefore, higher education educators and practitioners in both 2- and 4-year institutions should focus more on reasons behind Asian Americans' lower STEM attrition rates and pay attention to resources that they desire to maintain, if not exceed, their academic achievements in STEM.

For non-Asian minorities, this study does not suggest any relationships between race/ethnicity and the likelihood of obtaining a STEM degree. It is probably because these minority students have comparable learning experiences with White students at the 4-year university, as a large body of literature suggest that minority students with negative racial experiences are less likely to be committed to degree completion (e.g., Cabrera, Nora, Terenzini, Pascarella, & Hagedorn, 1999; Museus, Nichols, & Lambert, 2008; Nora, Cabrera, Hagedorn, & Pascarella, 1996). Educators and practitioners in both 2- and 4-year universities should continue their effort in creating an academic and social environment where students can celebrate their own racial/ethnic identities.

SES. The findings confirm evidence found in previous literature that SES factors (e.g., first-generation status, parents' education, family income) are significantly related to STEM degree completion (Anderson & Kim, 2006; Gayles & Ampaw, 2011; Shaw & Barbuti, 2010). The findings also add nuanced details concerning SES and STEM attrition by differentiating the two types of STEM dropouts (i.e., switchers and leavers). The findings indicate that SES factors do not associate with earning a degree in non-STEM fields, but low SES indicators are negatively related to leaving STEM without earning any degree. Given the fact that a high percentage of community college transfer students are from a low SES background, the disparities in STEM persistence associated with SES (i.e., the first-generation status and family

gross income) are particularly troubling, especially when the difference lies between earning a STEM degree and no degree at all.

A plausible reason for the high STEM attrition among SES disadvantaged students is their lack of social capital (Trenor et al., 2008). Social capital, or the value of relationships and networks that support individuals in a given social situation (Lin, 1999), has been widely applied to understanding gaps in educational achievements by student SES status. Researchers have indicated that, especially in the form of social support, social capital can benefit working-class, first-generation students, and students with low family income for their transition to a new environment and academic success (Lareau & Horvat, 1999; Pascarella, Pierson, Wolniak, & Terenzini, 2004). Researchers have also pointed out that these students need greater support from the institution than those with a higher SES background; however, unfortunately, these students tend to experience more difficulties locating resources on campus due to their lack of social capital (Moschetti & Hudley, 2015; Padgett, Johnson, & Pascarella, 2012). Therefore, to mitigate the adverse effects of low SES status on STEM persistence, both 2- and 4-year institutions should offer more targeted support to low-SES students as soon as they first enter college, and help them build networks and social relationships with faculty, advisors, mentors, and student affairs professionals throughout their entire higher education journey.

Pre-Transfer Academic Experiences

Aligned with the literature (Doyle, 2006; Monaghan & Attwell, 2015), findings of the study suggest that students with a higher number of transfer courses accepted by NTU are more likely to receive a STEM degree within six years than dropping out of STEM fields (i.e., switching to non-STEM fields or obtaining no degree). It is apparent that students who transferred more credit hours will need to take fewer courses at the university, and thus have a

higher possibility to graduate in a timely manner. As such, academic advisors at community colleges should help students who intend to transfer to a 4-year STEM degree program set up goals as early as possible and provide them with sufficient guidance on course-taking and transferring. To eliminate taking courses nontransferable to 4-year universities, academic advisors at community colleges could strengthen collaboration with their peers in 4-year STEM programs to provide pre-transfer students the most up-to-date course-taking requirements. Community colleges could also develop discipline-specific articulation agreements with their 4-year partners to better align curriculum in specific STEM majors. Findings of the study also suggest, for transfer students who enrolled in a STEM degree at their initial transfer, there is no relationship between earning an associate degree prior to transfer and obtaining a STEM baccalaureate degree within six years. While early studies (Crook et al., 2012; Ehrenberg & Smith, 2004; Kopko & Crosta, 2016) found evidence that students earned an associate degree had a higher likelihood of obtaining a bachelor's degree, none of these studies focused only on STEM entrants or STEM degree completion. A potential explanation of the non-effect of the associate degree is that many transfer students use community colleges as a safe zone to explore different academic interests, and the associate degree that they earned at the community college may not directly contribute to the STEM major that they choose to pursue at the 4-year university. Early research (Ehrenberg & Smith, 2004; Kopko & Crosta, 2016) also suggests that only transfer-oriented associate degrees are positively related to bachelor's degree attainment, but this study does not have available information about types (i.e., transfer-oriented or applied) or fields (i.e., STEM or non-STEM) of the associate degrees. Future research with consideration of such information could provide more insight into the impact of earning an associate degree on STEM attrition after transfer.

Post-Transfer Academic Experiences

This study found all post-transfer academic variables to be positively associated with transfer students' STEM degree attainment. Echoing the previous literature (Adelman, 2006; Wang, 2015; Zhang, 2019), the study findings highlight that both quantity (e.g., number of courses attempted and if withdrew any courses) and quality (e.g., first-semester GPA and highest mathematics completed) of transfer students' early academic experience matter for their degree attainment in STEM fields. It is not surprising that, when enrolled in more courses with no withdrawals, transfer students are more likely to complete required courses in fewer semesters, and thus graduate with a STEM degree in a timely manner. Similarly, when students receive a better GPA during the first semester, they have a higher likelihood of succeeding in more advanced courses in the following semesters, which in turn improves their persistence in STEM.

However, ample evidence has pointed out that community college students face greater challenges in their first semester when adjusting to a new learning environment, getting familiar with institutional policies, and locating campus resources at 4-year universities. Indeed, they often experience a decline in GPA, or transfer shock, in the first semester (Hill, 1965; Starobin & Laanan, 2008; Townsend & Wilson, 2006). The challenges can be even more prominent for those who are in math and science majors (Cejda, Kaylor, & Rewey, 1998). To better support these students, 4-year universities could develop new or improve current programs that amplify students' learning experiences and outcomes. For instance, empirical evidence suggests that a mandatory learning community for all incoming transfer students could improve their overall GPA and retention rates (Scott, Thigpin, & Bentz, 2017). Other evidence suggests that mentoring is effective in improving students' performance and persistence in STEM (Chang, Buonora, Kwon, & Stevens, 2016; Damkaci, Braun, & Gublo, 2017; Shadduck, 2017). Participating in

faculty-led research and community-based programs has also been found beneficial for students' success in STEM (Chang et al., 2016; Leggett-Robinson, Mooring, & Villa, 2015). By implementing or strengthening these programs, 4-year universities could greatly improve transfer students' experiences in transition and help them stay on the academic track.

As shown in the literature (Hagedorn & DuBray, 2010; Seymour, 2001; Seymour & Hewitt, 1997), math performance impacts students' STEM success and degree completion. Similarly, the findings of the study indicate that the most advanced mathematics course completed in the first semester is positively associated with 6-year degree completion in STEM. In STEM majors, eligibility to enroll in higher-level courses often depends on students' performance in prerequisite courses and their progress in mathematics. As such, it is not surprising that students who completed a higher level of mathematics courses during the first semester are more likely to persist in STEM. In addition to strategies discussed above, 4-year universities could focus more on foundation math courses, or gatekeeper courses, which do not only improve students' immediate achievement in mathematics, but also pave the way for future success in advanced math-based courses.

Conclusion

This study examined factors that impact STEM persistence and attrition among community college transfer students who aimed to pursue a STEM degree at their initial transfer to a large public 4-year research university in north Texas. The findings of the study reinforce achievement gaps by students' characteristics. In other words, when compared with the STEM persisters, switchers were more likely to be older learners, female, and non-Asian race/ethnicity. Leavers were more likely to be older, non-Asian, first-generation, and have low or middle family income. The findings also highlight the importance of early academic experiences for STEM

persistence and degree completion. STEM switchers and leavers were more likely to transfer a lower number of courses to the 4-year university, attempted fewer courses in the first semester, withdrew one or more courses, and received a lower semester GPA. In terms of mathematics preparation, they were less likely to complete calculus I and more advanced mathematics courses.

Overall, the findings of the study contribute to the current literature on STEM persistence and attrition, especially for STEM aspirants who transferred from a community college to a 4-year university. The findings also provide new knowledge about STEM attrition by comparing students who dropped out of STEM with or without earning a non-STEM degree. Although this study provides valuable information for faculty, researchers, and educational practitioners to better understand *who* the STEM persisters, switchers, and leavers are, it was not designed to explain *why* and *when* these students made decisions to persist in or depart from STEM, which are warranted closer scrutiny in the future research endeavor.

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