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Traditional vs. Affiliation Paths Model for Science Student Success

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ABSTRACT

The availability of academic and personal supports is known to have a positive impact on students' academic success, which can be particularly beneficial in the university setting. In the present study, we propose that participation in a university academic and climate support program increases students' academic success in the Science, Technology, Engineering, and Math (STEM) fields. The aim is to answer two research questions about the dynamics of the university setting as it relates to traditional higher education versus targeted support program's affiliation paths. Results gathered by comparing two groups (Minority Opportunities in REsearch (MORE)) programs affiliates versus non-MORE (or essentially traditional degree program paths), indicate that students affiliated with the university target program have much higher graduation rates. 88% of MORE students graduated in 6 years and 100% within 10 years, compared to non-MORE traditional students with 16% graduating in 6 years and 28% graduating within 10 years. Concerning the second research question of interest, all MORE STEM majors were compared by major while controlling for entry status of freshmen versus transfers. A two-way ANOVA showed there were no differences by major pointing to the generalizability of this type of support program.

Keywords: STEM, university program, underrepresented minorities, graduation rate

INTRODUCTION

Historically, students have been encouraged to enlist in extracurricular activities, affirming that they would benefit greatly from it. However, the degree of benefit varies depending on the type of program in which a student partakes. The availability of academic and personal supports is known to have an impact on students' academic success [5], which can be particularly beneficial in the university setting. In the present study, we investigate the argument that participation in a university biomedical support program increases students' academic success in a selection of Science, Technology, Engineering, and Math (STEM) fields. A possible reason is that such university programs facilitate student access to both academic and personal supports through structured program components. In turn, these efforts purport higher academic success by promoting higher self-efficacy, assisting with progress toward graduation, increasing graduation rates, encouraging higher GPAs, and offering more stability in one's chosen science major, among other outcomes. Students who did not participate in similar university programs may not reap the same benefits that participation in these programs may offer, such as mentorship, networking, research opportunities, and especially family outreach. Lacking this sense of connectedness to a community, students who do not participate in a targeted university support program may feel a sense of disengagement during their time at a university. Although not impossible, it can be substantially more difficult for non-affiliated students to build and/or benefit from a network of supports that university programs offer.

As part of this research, the Traditional versus Affiliation Paths model (see Figure 1a & 1b) was proposed by a research team coauthor which describes a theoretical dichotomous experience faced by students in a university setting. The Traditional Path illustrates the experience of students who do not participate in university programs and rely solely on themselves with minimal academic advisement to navigate higher education at a large urban university. Meanwhile, the Affiliation Path involves students who participate and receive support from enhanced curricular university support programs, such as the Minority Opportunities in REsearch (MORE) Programs, a biomedical support program at California State University, Los Angeles (Cal State LA). These paths were generated based on internal research of students affiliated with the MORE programs. In a preliminary 10-year study it was initially noted that chemistry students involved with the MORE programs had an 80% graduation rate, compared to the 10% graduation rate of typical freshman chemistry students at Cal State LA overall. Students in the MORE programs had access to research experience, academic support, intensive mentoring, family outreach and financial aid. It was theorized that these program components created a micro-climate within Cal State LA which helped support student needs that resulted in higher persistence in chemistry culminating in graduation. In the present study, we seek to formally research the evidence as whether the Traditional versus Affiliation Paths Model can be used to explain the dynamics that occur in the university setting and then discuss possible factors that differentiate these two groups.

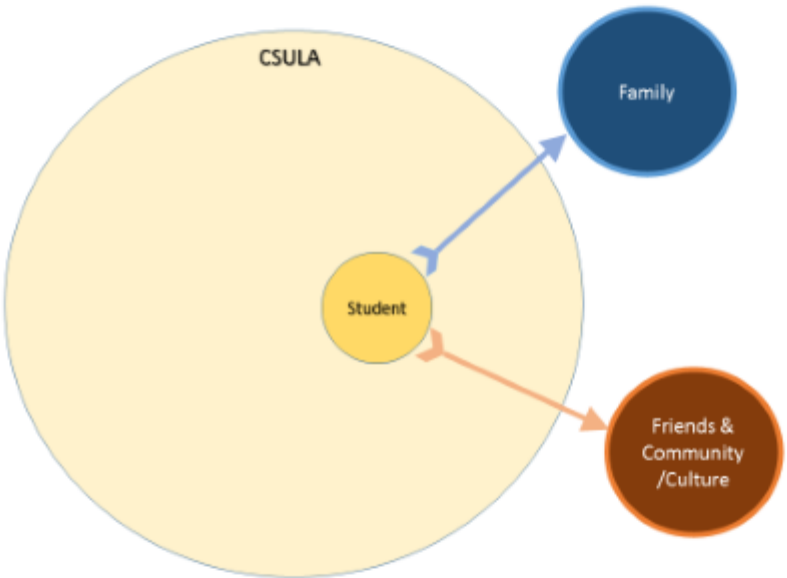

Figure 1a. Traditional Path

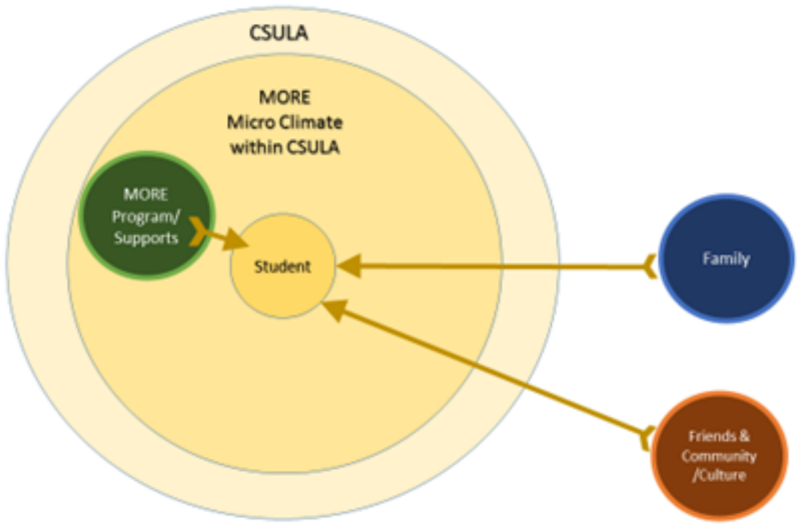

Figure 1b. Affiliation Path

The two clear guiding research questions driving this study are:

1. Can the Traditional versus Affiliation Paths Model to earn a degree hold up under empirical studies?
2. Is there a difference in time to degree of affiliated students that depends on a student's major?

CONTEXT

In 2012, Slovacek, Whittinghill, Flenoury, and Wiseman [14] conducted a study that examined 8 years of data on MORE and non-MORE undergraduate students to determine whether the MORE programs promoted student persistence in the sciences and encouraged continuation into graduate school. Consequently, they found that students who participated in the MORE programs graduated at higher rates and were less likely to change out of their science majors or drop out of college. In addition, MORE affiliated undergraduate students tended to pursue graduate programs at higher rates than non-MORE students [13, 14]. However, regardless of affiliation to a program, previous research found that there was a slight negative tendency overall in students' intentions to pursue a research career in science [13], essentially a net out migration to other perhaps easier majors. Although this trend may be due to various factors, programs must employ the most beneficial components that encourage students to not only complete a degree in science, but pursue a science-related career since this is an area of high need. According to Slovacek, et al. [13], students perceived certain program components as more "helpful" than others. Students in the MORE programs attributed research-based interventions, consistent support from STEM faculty research mentors, and supplemental instruction as most effective for their success. Based on this prior research, it seems that participation in the MORE programs fostered a community where students became more committed and involved in their fields. In addition to particular program components that were somewhat more effective in yielding these results, the MORE program provided scholarships and financial support. Students enjoyed "protected time" to pursue their academic work and research lab work free from needing to work off-campus in a job unrelated to research or majors to pay the bills.

These findings are aligned with those of Barlow and Villarejo [3], who conducted an evaluation of the Biology Undergraduate Scholars Program (BUSP) at the University of California, Davis. The program was created to address racial and ethnic disproportions in graduation rates in the field of biological sciences through academic, financial, and support services ([3]. In their study, Barlow and Villarejo [3] discovered that students affiliated with BUSP showed higher rates of persistence and performance than non-BUSP students in a series of required courses. In addition, there was a significant difference in graduation rates among BUSP affiliates who participated in research versus those who did not; those who participated in research were more likely to graduate. This is commensurate with the MORE programs findings that specific program components are an important factor to consider. Interestingly, even though about half of the students reported having a negative research experience in that study, they also indicated that having participated in research had influenced their choice in major [3]. Regardless of students' experience with research, the evaluation determined that programs such as BUSP can have a significant role in boosting minority representation in STEM.

Clearly, there are various factors that impact students' persistence in STEM majors and completion of degree. For students new to higher education, success can depend on how well they adjust to the new academic environment and the extent to which they feel a sense of belonging. Coincidently, academic adjustment and sense of belonging are strongly linked [9]. Because these are not standalone concepts, it is important to take context into consideration when discussing these concepts. More specifically, it is important to keep in mind that certain groups of students experience higher education from a different lens based on their cultural background. For instance, Hurtado et al. [9] found that underrepresented minority students in their sample were more highly concerned with financing college in comparison to other students. Moreover, students with additional family responsibilities that interfered with college resulted in negative effects on both academic adjustment and sense of belonging [9]. However, students who were more confident in themselves, could communicate with faculty, and had good time management were able to offset these effects because these features led them to take advantage of resource available to them [9]. This leads one to believe that even though there are uncontrollable forces that influence student success, there are also protective factors that university programs can capitalize on to support students.

Many protective factors for students in higher education that foster a sense of belonging involve interaction with peers, whether it be from someone with higher academic standing or a diverse racial background [9]. A "critical mass" of students has been theorized to be an essential component of fostering community. In the past, critical mass was defined as "a strong minority of 15%" [6], but some argued that it should be expressed in ranges rather than a specific number [1]. Still others still thought that the name should be changed because looking at numbers alone was not enough [7]. Addis [1] argued that the term critical mass can only be conceptually understood as an analogy of its scientific definition "the amount of radioactive material that must be present for a nuclear fission explosion to occur". In non-scientific domains, Addis [1] explained, critical mass is "a threshold of actors needed for the tipping-in or tipping-out of social activities and social norms in educational institutions". Put simply, critical mass is the amount of individuals in a group, which varies in number, needed for bonding to occur. However, it was further clarified that the critical mass analogy is not exactly transferrable, outside of science, because groups of people are sensitive to contextual factors.

Garces and Jayakumar [8], rationalized that in order to understand critical mass, which they called "dynamic diversity", one must understand the conditions necessary for participation and meaningful interaction to take place. They went on to describe "dynamic diversity" as interdependent on institutional components such as number of students of color on campus and/or classroom climate [7]. Addis [1], had similar ideas, asserting that a certain critical mass depends on the "size and nature of the entering class", as well as the type of institutional framework where student interactions take place.

As demographics in higher education institutions have continued to change over the past few decades, there has been a rapid growth of Hispanic-Serving Institutions (HSIs) in the U.S. [8]. According to the Hispanic Association of Colleges and Universities [8], an institution must have at least 25% full-time Hispanic student enrollment to qualify a university with HSI status. In the 2018-2019 academic year, Cal State LA enrolled 54% full-time Hispanic students based on the Enrollment Reporting System (ERS) that collects data frequently on all California State University campuses. With this U.S. government designation, the assumption is that having a critical mass of at least 25% Hispanic students encourages the university to adapt to the needs of the Hispanic population and better serve them [12]. One way to cultivate student success is to secure supportive staff, since staff support and commitment have been observed to be major drivers of diverse student recruitment and retention regardless of race or ethnicity [11]. This is something university programs can use to their advantage considering that there is still a lack of representation of minorities in the higher education setting, especially because university staff do not have to identify as the same race or ethnicity of the student population to have a positive impact on them [11].

Aside from interactions with peers and faculty, the university climate also impacts the outcome of students' experience. According to Cohen, McCave, Michelli, and Picckeral [4], fostering a positive school climate is "associated with and/or predictive of academic achievement". The National School Climate Center [10] defines school climate as, "the quality and character of school life". They go on to explain that school climate is reflective of various aspects of people's experiences, such as norms, values, practices etc., which can affect development and learning. However, the way in which it affects students depends on whether the school climate is positive or not. Cohen et al. [4], recommend that cultivating a positive school climate begins with preparation of educators in order to create positive relationships and promote a sense of community. Although there are no specific guidelines for sustaining a positive school climate, Cohen et al. [4] suggest focusing on four aspects that influence school climate: safety, teaching and learning, relationships, and environment/structure. Each of these aspects affect students' experience and have the potential to influence student outcomes to some degree. University programs further create a microclimate within the school setting by establishing an environment that has the potential to influence a small number of students on a daily basis depending on various program components. Regardless of the how positive the school climate is, or the degree to which a student adjusts and feels a sense of belonging in the university setting, even the most optimum conditions are still susceptible to adverse effects.

In fact, self-efficacy theory has been proposed to be related to student adjustment [15]. Solberg et al. [15] define self-efficacy simply as, "the strength of a person's belief that they are able to produce a given behavior." In the university setting, self-efficacy relates to the level of confidence students have about accomplishing school-related tasks [15]. According to Albert Bandura [2], the originator of this theoretical construct, self-efficacy could either help or hinder a person's actions, especially in relation to goal-setting. He stated that most human behavior is regulated by the goals that they set, which means that a person's perception of their self-efficacy could either lead them to seek to achieve that goal or stop them from trying [2]. This is particularly of importance when creating university programs for students in STEM, since STEM programs can be quite rigorous. Students who do not have a strong sense of self-efficacy may have more difficulty persevering and overcoming adversity, especially when flooded with self-doubt. Students' levels of self-efficacy can also affect the amount of motivation they possess which determines how much effort they employ in various tasks [2]. One may conclude that students who have a strong sense of self-efficacy are more likely to persist in their chosen fields, more easily overcome challenges, have higher motivation, exert more effort, and graduate at higher rates. If true, it is imperative that university programs make aim to incorporate program components that fosters students' self-efficacy. However, this is a topic that should be explored with further research in the future.

What the research findings above validate is the importance of community and university support to promote students' academic success. Clearly, the research suggests that an HSI environment alone is not enough. However, the MORE programs at Cal State LA created a microclimate within the university which has served as a support system by providing students in the biomedical STEM fields with a cohort of like-minded individuals, resources to carry out their career plans, and an environment that nurtures students' scientific identity. Additionally, efforts to involve students' family and friends further bolstered a supportive environment by encouraging interactions between students' personal and academic lives. All of these components combined give affiliated students the support they need to be successful in their fields; support that traditional students may not always receive.

METHODOLOGY

To answer the two guiding research questions, we employed various methods of data collection and analysis. In this section we further discuss the methods used to respond to each question.

Research question 1. Can the Traditional versus Affiliation Paths Model to earn a degree hold up under empirical studies?

While there are numerous types of empirical studies including , but not limited to retention rates, graduation rates, GPA's, staying power within initial degree choice, and subsequent programs, the researchers chose graduation rates as the key outcome variable. Being in the Traditional versus Affiliated path was the main independent variable.

Research question 2. Is there a difference in time to degree of affiliated students that depends on a student's major?

We conducted a two-way ANOVA to address these questions. Students' majors within MORE were compared after controlling for university entry status (freshman versus transfer) to compare the time it took to earn a degree. The prediction variables being traditional versus microclimate environment and entering class level. The dependent variable is, of course, time to earn one's degree.

Data Sources. Every year the California State University (CSU) Chancellor's office conducts a series of surveys to gather information regarding graduation and retention rates among students in the CSU campuses. Data is organized by groups such as first-time freshmen and transfers from a community college, then separated into cohorts by campus, ethnicity and gender. These cohorts are then tracked on a yearly basis to calculate graduation and continuation rates over a period of 10 years.

First we compared graduation rates between students affiliated with the MORE programs versus students in similar STEM majors at Cal State LA. The Chancellor's office provides data most recently collected between 2007 and 2016. To compose a comparative group, we accumulated historical student data from the MORE programs based on major, entry status, entry date, graduation date, and time to degree. We then used that rather large comparison group of non-MORE students to assess differences. A potential limitation is that the Chancellor's office uses an overly broad definition of STEM which includes engineering and math in addition to the sciences. Engineering (which includes technology) and math have historically been much smaller programs at Cal State LA until very recent years.

FINDINGS

When looking at all first-time freshman at Cal State LA enrolled in STEM majors beginning in 2007, only 16% had graduated within 6 years (see Figure 2). This number increased to 28% for first-time freshman who graduated within 10 years. Data shows that students affiliated with the MORE programs during this same time period graduated at higher rates. Within 6 years, 88% of MORE students enrolled in STEM majors had graduated. By the 10-year mark, nearly 100% of MORE students in the study had graduated from Cal State LA.

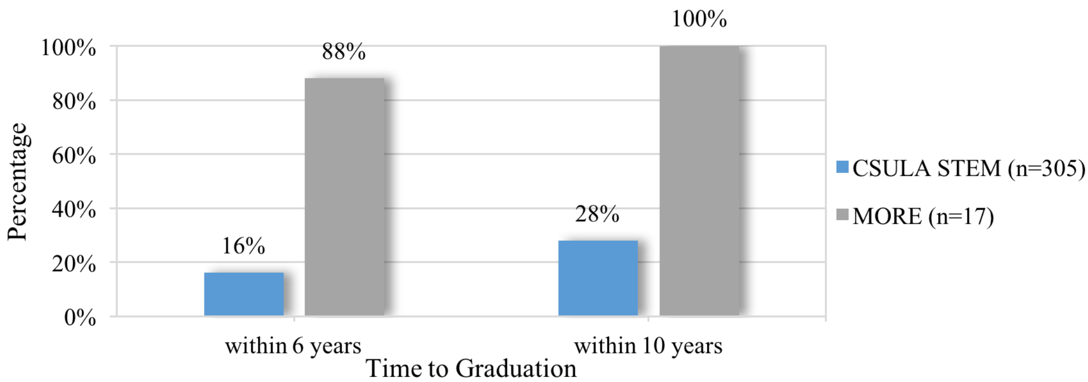

Figure 2. Graduation Rates for 1st Time Freshmen (2007) at Cal State LA

Analysis of transfer student data at Cal State LA yields similar results. The Chancellor's Office does not provide data regarding transfer students enrolled in STEM majors. However, when comparing graduation rates between transfer students who began studying at Cal State LA in 2007 overall and those who participated in the MORE programs during that time, we see that students affiliated with the MORE programs exhibited higher graduation rates. While 65% of transfer students graduated within 6 years, 98% of transfer students in the MORE programs graduated within that time. There is a positive graduation trend for both groups over time, but only 69% of Cal State LA transfer students had graduated within 10 years compared to 100% of MORE transfer students. Note, the researchers only found one MORE student who dropped out of the program.

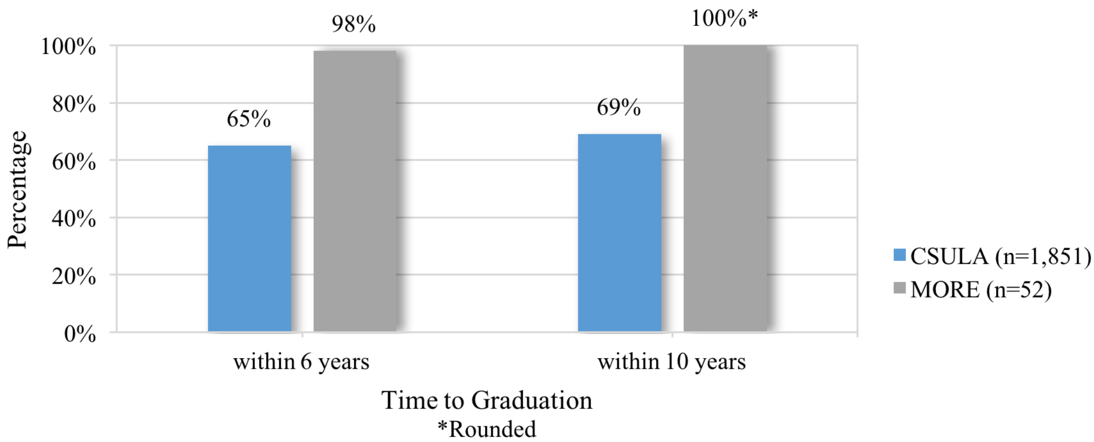

Figure 3. Graduation Rates for Transfer Students (2007) at Cal State LA

Two-way ANOVA. A two-way ANOVA was conducted comparing differences in time to degree for each MORE student degree field and student entry status (freshmen vs transfer). The years encompassed in this study were from 2007 to 2016. Multiple databases were used so the numbers in this study may be lower than MORE records.

Results (table 1) showed that the overall predictive model is significant (F-value of 6.636, P-value (sig) of .000) and the student's entry status is also a statistically significant predictor (F-value of 38.171, P-value (sig) of .000). The interaction term (Entry Status*Time To Degree) is not significant (F-value of .997, P-value of .417). This suggests that the factors, freshmen and transfer entry status, acts in the same way in predicting time to degree. Overall mean time to degree for first-time freshman was 5.138 years compared to 3.076 years for transfers which would be expected since transfers typically have already completed some of their other degree requirements at community colleges.

Table 1 Two-way ANOVA – Dependent Variable: Cal State LA Time to Degree

Source	Type III Sum of Squares	dF	Mean Square	F	Sig.
Corrected Model	83.774[a]	10	8.377	6.636	.000
Intercept	667.239	1	667.239	528.576	.000
Entry Status	48.185	1	48.185	38.171	.000
Time to Degree	18.458	5	3.692	2.924	.020
Entry Status*Time to Degree	5.034	4	1.259	.997	.417
Error	73.215	58	1.262		
Total	1035.460	69			
Corrected Total	156.990	68			
a. This level combination of factors is not observed, thus the corresponding population marginal mean is not estimable.					

Table 2 *Entry Status Means*

Entry Status	Mean	Std. Error	Lower Bound	Upper Bound
First Time Freshman	5.138[a]	.320	4.497	5.779
Transfer Student	3.076	.162	2.752	3.399
a. Based on modified population marginal mean.				

Table 3 *Entry Status Estimated Marginal Means – Dependent Variable: Time to Degree*

Entry Status	Degree	Mean	Std. Error	Lower Bound	Upper Bound
First Time Freshman	Biochemistry	5.550	.562	4.425	6.675
	Chemistry	4.800	.562	3.675	5.925
	Biology	4.840	.502	3.834	5.846
	Psychology	3.800	1.124	1.551	6.049
	Microbiology	6.700	.649	5.402	7.998
	Other STEM	.[a]	.	.	.
Transfer Student	Biochemistry	2.943	.425	2.093	3.793
	Chemistry	2.829	.300	2.228	3.430
	Biology	2.600	.375	1.850	3.350
	Psychology	2.843	.425	1.993	3.693
	Microbiology	3.256	.375	2.506	4.005
	Other STEM	3.983	.459	3.065	4.901
a. This level combination of factors is not observed, thus the corresponding population marginal mean is not estimable.					

As figure 4 below illustrates, first-time freshman and transfer students typically differ in mean time to degree at Cal State LA as would be expected. This is typical in nearly all university settings, as transfer students have already completed general education courses at a different institution. However, results also show that time to degree differs some based on type of degree (biochemistry, chemistry, biology, psychology, microbiology, other STEM). These differences are more apparent for first-time freshman but exist consistently among transfer students as well. For instance, mean time to degree among first-time freshman ranges from a mean of 3.8 years in psychology to 6.7 years in microbiology. Meanwhile, time to degree for transfer students ranges from 2.6 years in biology to 4 years in other STEM fields.

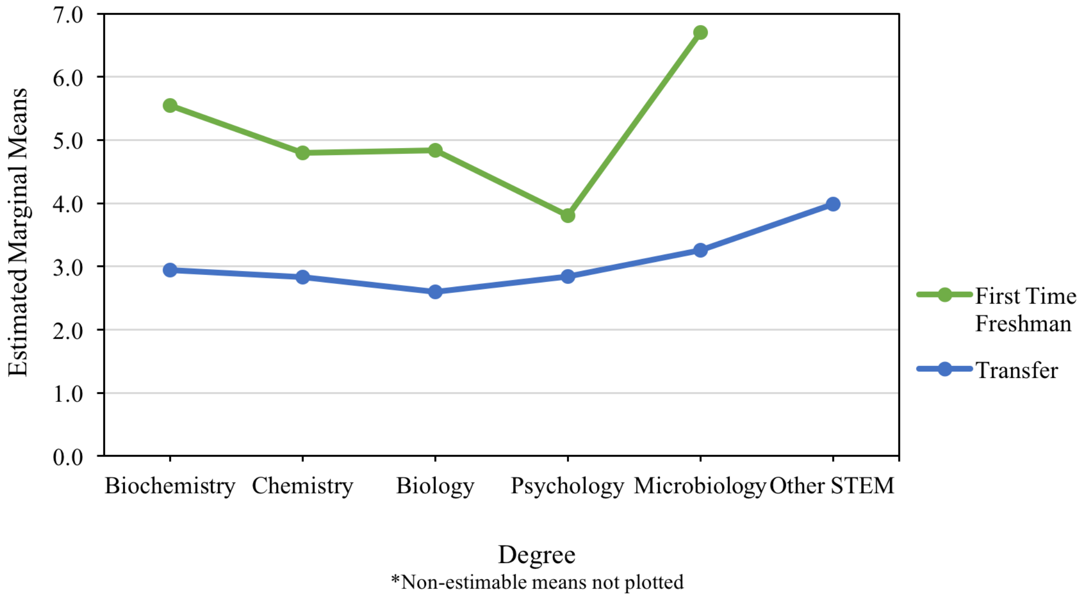

Figure 4. Time to Degree Based on Entry Status and Major

DISCUSSION

The researchers found a profound and positive effect of the Affiliation path to a degree through the MORE support program. The rate of completion to graduation was almost four times as high compared to similar major students in the Traditional path. Concerning the second research question, it appears that MORE students do not differ on graduation rates depending on majors. In other words, students in the affiliated program were statistically equally likely to succeed regardless of major, in graduating sooner than non-MORE students. As for the limitations of the study, the researchers focused on graduation rates. In defense of this focus, that clearly is the main objective of most students entering the university. Another challenge was that there was no easy way to secure university data specifically targeting transfer students in STEM majors to compare to MORE transfer students. The researchers used existing data from multiple sources, including program records of student participation from the MORE office, university graduation records, and CSU Chancellor's office data for graduation rates over time.

Further research along the lines pursued here involving multiple universities and colleges with similar programs would benefit from a study of the self-efficacy levels of MORE affiliates versus a sample of comparison students. Also, the percentage of students of each of these groups who go on to pursue and succeed in PhD study would be useful if a larger number of university cases could be studied and funds were available for significant longitudinal research study.

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