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Examining STEM Performance within a Comprehensive College Transition Program

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Abstract. We examine the impact of the Thompson Scholars Learning Community (TSLC), a comprehensive college transition program serving students with a variety of majors, on students' science, technology, engineering, and math (STEM)-related outcomes. We use an explanatory mixed-methods design, which prioritizes the quantitative analyses and uses qualitative analyses to contextualize and explain our quantitative findings. Overall, participating in TSLC does not make students more likely to declare a STEM major, although we do find a positive effect for students of color. TSLC students earn higher overall GPAs than their scholarship-only peers, and TSLC students majoring in STEM outperform scholarship-only STEM majors in STEM courses. Qualitative analyses suggest these results stem from the student-centered and proactive support the program provides students. Our results suggest that a disciplinarily-agnostic program can support student success in STEM, and may increase equitable representation in STEM fields.

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Examining STEM Performance within a Comprehensive College Transition Program

Degrees in certain science, technology, engineering, and mathematics (STEM) fields have the highest wage premium among all bachelor's degree fields (Carnevale et al., 2015; Greenwood et al., 2011; Melguizo & Wolniak, 2012; Hershbein & Kearney, 2014; Funk & Parker, 2018). There are also concerns that the United States is not producing enough graduates with STEM credentials (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine [National Academies], 2007). Students majoring in STEM fields are more likely than students in other fields to change majors during their first three years (National Center for Education Statistics, 2017). Students majoring in STEM tend to earn lower grades in their major-specific courses than students majoring in their major-specific courses, potentially driving disproportionate rates of major-switching among STEM majors (King, 2015). Increasing the number of college graduates prepared to enter the STEM workforce therefore entails not only shifting students into STEM majors, but also supporting students' achievement once they have declared a STEM major.

In addition to overall concerns about the number of students who graduate with a STEM degree, policymakers are also considered about inequities in representation in STEM. Women, students of color, and students from low-income backgrounds are underrepresented in, and at increased risk of leaving, STEM majors in higher education (National Science Foundation, 2019; Chen & Soldner, 2013). These persistent disparities have led to calls for increased representation of women and people of color in STEM fields (e.g. Bensimon et al., 2019; Rose, 2019). Estrada et al. (2017) highlighted the need for institutional analysis of students' interest in, and completion of, STEM majors; working within programs on campus to support students' success in STEM; incorporating proven pedagogical and curricular strategies into STEM courses;

providing additional resources and support for underrepresented students; and making STEM content culturally relevant to increase the representation of women and people of color in STEM. Similarly, researchers have found that STEM-focused learning communities can increase retention in STEM, particularly for traditionally underrepresented students (Kezar & Holcombe, 2019; Soldner et al., 2012).

Recently, educators have explored supporting student success through comprehensive college transition programs (CCTPs) that provide students with a rich array of support services designed to meet students' financial, academic, social, and personal needs (Hallett et al., 2020). Research on CCTPs such as the Accelerated Study in Associate Programs (ASAP) in New York, the national Dell Scholars program, and the Carolina Covenant in North Carolina have suggested they are a viable means of increasing student success (Scrivener et al., 2015; Page et al., 2017; Clotfelter et al., 2016), and institutions and researchers are increasingly interested in replicating and expanding these types of interventions. The National Academies of Sciences, Engineering, and Medicine (2017) has called for additional work examining the role of comprehensive, college transition support in promoting success for underrepresented students in STEM. In this paper, we use mixed methods to examine the impact of one such CCTP on the likelihood that students will declare a STEM major as well as students' academic performance, overall and in STEM courses.

The Thompson Scholars Learning Community (TSLC) is a privately funded CCTP that has been operating at the three main campuses of the University of Nebraska system since 2008. TSLC provides five years of financial support (up to $60,000) as well as two years of intensive, structured programming and services for students, including course sections reserved for TSLC scholars taught by faculty who are partially selected, funded, and trained by TSLC; regular meetings and advising from program staff; peer mentoring; a seminar focused on building skills related to academic success; social events; workshops; and housing and/or study spaces on campus. In students' third year and beyond, the formal requirements of the program fade, but students can still connect with peers and staff, work as peer mentors or in TSLC offices, and are required to meet with staff if placed on academic probation from the scholarship. We discuss TSLC and why we hypothesize participating in TSLC may be related to STEM outcomes in greater detail later in the paper.

We leverage an experimental evaluation of TSLC for our quantitative analyses. We focus on two cohorts of students entering in 2015 or 2016 and specifically on the comparison between students randomized to the TSLC and students who receive the same scholarship without the two years of comprehensive support. We utilize student-level interview data for the qualitative portion of the paper. All qualitative data was obtained from students participating in TSLC, some of whom were not randomized into the program but instead were directly selected by the sponsoring foundation. The specific methods used for each analysis, as well as how they complement each other, is described in the Methodology section.

Angrist et al. (2014; 2016) have estimated the impact of receiving support from the STBF (whether TSLC or COS) on students' postsecondary outcomes, finding positive impacts of both TSLC and the COS on the likelihood that students will enroll in a four-year institution, persist, and graduate within six years relative to receiving no support. While Angrist et al. (2016) find no differences in outcomes between students in the TSLC and COS groups during students' first four years, Melguizo et al. (2019), drawing on longitudinal survey data from TSLC and COS students in the 2015 and 2016 cohorts, find positive impacts of participating in TSLC relative to the COS on students' sense of belonging to campus and mattering to campus. Qualitative analyses of TSLC, based on over 1,000 interviews with students, staff, faculty, and stakeholders conducted over three years, found that TSLC supported students' success and psychosocial outcomes by creating an ecology of validation that proactively affirmed students, integrated the different program components, and blended personal and academic support for students (Hallett et al., 2020). While TSLC is not targeted towards students interested in STEM fields, it does provide comprehensive supports intended to improve students' academic performance, engender a sense of belonging and mattering to campus, foster peer relationships, and bolster students' confidence in their abilities for all participants. By providing these supports and improving students' psychosocial outcomes, TSLC may help students in STEM fields achieve at higher levels than students without similar support, and may increase the representation of students of color and women in STEM by validating students' abilities and reinforcing their sense of belonging.

We employ an explanatory mixed-methods design (Teddlie & Tashakkori, 2009), which prioritizes the quantitative portion of the study over the qualitative (Ivankova et al., 2006). We leverage the random assignment of students to either the TSLC or COS condition for our quantitative analysis, drawing on data provided through the longitudinal student survey and administrative data provided by the University of Nebraska system. We use cross-comparative thematic analysis of student-level case summaries to contextualize and explain our quantitative findings.

In this paper, we address the following research questions:

1. Are students randomly assigned to TSLC more likely to declare a major by the end of their second year, or a STEM major by the end of their third year on campus, than students randomized to the COS condition?

2. Do students randomly assigned to TSLC earn a higher overall GPA than students randomized into the COS condition; similarly, do TSLC STEM majors outperform COS STEM majors in STEM courses?
3. Are there heterogeneous effects to the above research questions by student race/ethnicity or gender?
4. What experiences do students have with the program that could explain the relationships we see quantitatively?

We find no impact of participating in TSLC on the likelihood that students will declare a major by their second year or that they will declare a STEM major; however, we do find positive impacts of TSLC participation on STEM major declaration for students of color. Students who participate in TSLC earn higher overall GPAs than their scholarship-only peers; similarly, among students majoring in STEM field, TSLC students outperform COS students in STEM courses. We find limited evidence of heterogeneous effects by race/ethnicity or gender when looking at academic achievement. Our qualitative analyses suggest TSLC may produce these outcomes by providing student-centered, proactive support.

I. Improving Outcomes in STEM

There are positive returns to earning a bachelor's degree, regardless of major (Carnevale et al., 2015; Smith et al., 2020), and students have many factors to consider when deciding on a major, including potential future earnings, interests, and aptitudes. While there is no optimal major decision for all students, it is a policy concern that the United States is not producing enough undergraduate or graduate STEM degree holders (National Academies, 2007) and, in particular, that students of color and female students are underrepresented in the STEM fields (National Academies, 2011; National Science Foundation, 2019; Chen & Soldner, 2013). This discussion is particularly relevant for TSLC, as all TSLC students are low-income, 69% are first-generation, 40% are students of color, and 63% are women. Here, we draw on theory and prior literature to demonstrate why TSLC participation may affect STEM outcomes.

Economic and psychological theory

Students' perceived value of a STEM degree is shaped not only by about average salaries (e.g. Becker, 1964), but also their self-assessed likelihood of success in STEM courses and on the job market. TSLC supports students in exploring majors and careers by providing opportunities to reflect, explore, and learn about possible career paths. For example, one campus brings in a career consultant to assist students in completing a career workbook activity and making sense of their results to assess their skills and interests and their alignment with particular career paths (Kezar et al., 2020). This opportunity may help students see STEM as a viable major and career path for their skill set and interests, or may reaffirm students' capabilities in STEM for those who already have expressed interest in a STEM field, potentially increasing the likelihood that TSLC students will declare a STEM major (Deci & Ryan, 1985; Durik et al., 2015; Arcidiacono et al., 2012). Further, TSLC provides students with dedicated study spaces, required study hours, and tutors. These services could help TSLC students achieve at higher levels than their COS peers.

Sense of belonging interventions

Women, and particularly women of color, tend to report lower levels of belonging in STEM; these self-reports are related to lower levels of achievement and an increased likelihood of exiting STEM majors (Stout & Ito, 2013; Rainey et al., 2018). Interventions that foster a sense of belonging can improve student performance in STEM courses (Kirp, 2019; Xu et al., 2018) and counterbalance the inequities that lead to racial and gender differences in achievement

(Walton & Brady, 2017; Strayhorn, 2011). By increasing students' sense of belonging to campus (Melguizo et al., 2019), TSLC may help students feel more confident in STEM classrooms, thereby encouraging students of color and women to declare STEM majors.

While TSLC is not focused specifically on STEM, it does work to increase students' sense of belonging to campus as well as students' feelings of mattering, which captures the extent to which students feel that they are valued by institutional agents (such as staff and faculty) on campus. Additionally, by using validating practices (Rendon, 1994) while advising students and reviewing their academic performance, TSLC may be particularly well-positioned to help students build on their successes, access support, and achieve at higher levels than their non-TSLC peers. Finally, as a program, TSLC is identity conscious (Pendakur, 2016) in how it supports students, and works to hire and retain a diverse staff. This programmatic commitment to diversity and equity could promote greater representation of students of color and women in STEM fields among TSLC students than among COS students.

Learning communities and comprehensive college transition programs

Learning communities integrate students' academic and personal experiences by creating a single hub where students can make friends, participate in events, connect with faculty, receive advising, and study with their peers (Inkelas et al., 2018). Participating in STEM-focused learning communities has improved students' performance in introductory chemistry, calculus, and biology courses (Inkelas et al., 2018; Xu et al., 2018; Windsor et al., 2015), as well as boosted students' sense of belonging and persistence (Xu et al., 2018; Kezar & Holcombe, 2017; Windsor, et al., 2015), and indirectly increased intentions of earning a STEM degree (Soldner et al., 2012). Such communities may be particularly powerful for female students generally and female students of color in particular (Solanki et al., 2019). In studies examining STEM-focused learning communities, researchers have documented the importance of faculty and campus staff coordinating efforts to support students of color and low-income students in STEM (Kezar & Holcombe, 2017; Freeman et al., 2008).

Similar to learning communities, comprehensive college transition programs integrate and address students' academic and personal needs. However, CCTPs can be distinguished from learning communities by the financial support they provide as well as the holistic services offered. While CCTPs may not typically focus specifically on students in STEM, they are proven improve student outcomes, particularly in terms of initial enrollment, GPA, persistence, and degree completion (Bloom & Sommo, 2005; Clotfelter et al., 2016; Page et al., 2017; Visher et al., 2012; Weiss et al., 2014; Evans et al., 2017; Angrist et al., 2016). TSLC, as an example of a CCTP, offers us the opportunity to evaluate whether a disciplinarily-agnostic program that provides comprehensive support and improves students' psychosocial outcomes, can also increase participation and success in STEM, for all students and for students of color and female students in particular.

II. The Intervention: Thompson Scholars Learning Community

The Thompson Scholars Learning Community (TSLC) is a comprehensive college transition program (CCTP) (Hallett et al., 2020) designed to provide comprehensive support to students from low-income backgrounds to increase postsecondary persistence and degree completion. In order to be eligible for TSLC, students must have an expected family contribution of $10,000 or less and graduate from a Nebraska high school. First-time college students submit an application that includes an essay and two recommendations in addition to a standard questionnaire with demographic information. Students in TSLC receive a scholarship of up to $60,000 over five years and an array of academic and social supports during their first two years on campus, as outlined in Figure 1, although each campus customizes the specific services it provides to students.

One focus of the program is on preparing students for their intended major and career path, especially in the second year. TSLC provides a variety of supports for students during this process, holding workshops that allow students to explore different majors, requiring students to attend career fairs on campus, meeting with professionals in various fields, completing self-assessments of their interests and strengths, and finding internships related to their major and career interests (Kezar et al., 2020). The program also curates a series of major and career related activities both within and beyond the program early on in students' program experience and staff engage students in sense making round their experiences in those activities to support career development and confidence in a major and career path (Kezar et al., 2020). Prior research on the program has illustrated the critical role of program staff in connecting students to sources of information and experiences, within and beyond the program, to help students make decisions about the major and career path that is most suitable for them given their goals (Kezar et al., 2020). Staff advisors also help students make sense of their major and career related experiences within and beyond the program, through proactive one-on-one meetings with students. While previous work on TSLC focused on students' commitment to major and career paths regardless of discipline, these programmatic activities could also help students who are interested, but unsure of their abilities, enter or remain in STEM.

Another key focus of TSLC is promoting academic success. The program offers a number of activities with the goal of leading students to perform at higher levels than their peers who do not have access to the same level of academic support. For example, TSLC students may take some of their introductory STEM courses as shared academic courses: smaller course sections taught by faculty recruited by TSLC because of their commitment to active learning techniques, first-generation students, or improving student outcomes. TSLC students also have access to tutors, peer study groups, peer mentors, and staff who may help them with their STEM coursework or connect them to resources on campus to achieve their academic goals in their STEM coursework. The program requires concentrated study hours for students. Additionally, program staff use proactive academic advising techniques, such as meeting with students mid-way through each semester to monitor their academic progress and offering strategies for achieving their academic goals (Kitchen et al., 2020). This proactive advising incorporates interpersonal support in acknowledgment that personal issues can affect students' academic success. The resources offered by TSLC are intended to help all students succeed, but they may be particularly relevant for students who are in or considering STEM majors and careers in light of their challenging nature and, for underrepresented students, potentially hostile environments.

III. Methodology

Data for this study are drawn from a larger, longitudinal (2015-2020), mixed-methods evaluation of the TSLC program. This paper uses an explanatory mixed-methods design (Teddlie & Tashakkori, 2009). Mixed-methods research synthesizes strengths of quantitative and qualitative research and helps to moderate limitations associated with mono-methods, providing a fuller, richer understanding of the phenomenon under study (Creswell, 2014; Johnson & Onwuegbuzie, 2004; Leech & Onwuegbuzie, 2009). The present mixed methods study integrates information from our study at the analysis and interpretation stage, a common approach in mixed-methods research (Creswell, 2014; Johnson & Onwuegbuzie, 2004). We use theory and prior literature to guide our quantitative analyses, then draw on our qualitative data to help explain or contextualize our quantitative findings. This approach allows us to present rigorous, causal estimates of the impact of participating in TSLC on students' STEM outcomes as well as discuss evidence-based explanations for why the program produces those outcomes.

A. Quantitative Analyses

Randomization

Beginning in 2013[1], students who applied for a scholarship from the Susan Thompson Buffett Foundation (STBF), which funds TSLC, were assigned to one of five conditions based on their application score as determined by STBF staff (Angrist et al., 2014). The first group of students, with the highest application scores, were awarded a scholarship and a spot in TSLC by the foundation (must-funds). The second group scored above the threshold for scholarship eligibility and were randomly assigned to receive a scholarship and participate in TSLC (randomized-TSLC). The third group scored above the eligibility threshold for a scholarship and were randomly assigned to receive a scholarship, but not to participate in TSLC. (COS [the scholarship is called the College Opportunity Scholarship]). The fourth group scored above the scholarship eligibility threshold and were randomly assigned to a control condition in which they did not receive support from the STBF. The fifth group did not score above the threshold for a scholarship and did not receive any support from the STBF.

Must-fund students' participation in TSLC is endogenous, as their selection by the foundation is likely correlated with unobserved characteristics, such as writing ability or support networks, that are also correlated with their postsecondary outcomes. We therefore exclude this group from our quantitative analysis. Similarly, we exclude the students whose application scores were too low to be considered for support from the STBF. Students in the experimental

[1] The evaluation began in 2012 with four arms (non-experimental must-funds, experimental scholarship, experimental control, non-experimental no support). In 2013, researchers added a fifth arm allowing them to differentiate between participation in TSLC and the COS. In 2015 the STBF instituted a survey to evaluate the impact of TSLC on students' psychosocial outcomes as well as academic outcomes.

sample were randomized within strata defined by their intended campus of enrollment (any campus in the state of Nebraska).

Sample

Our data include students from two cohorts who first enrolled in college in the 2015-16 or 2016-17 academic year and who initially targeted an NU campus on their application to the STBF. We include six semesters (three years) of data for each cohort. Students' initial randomization into the randomized-TSLC (hereafter, TSLC) or COS conditions on the one hand or control condition on the other had a large and significant impact on their initial enrollment decisions (Angrist et al. 2014). Table 1 shows attrition from the original randomization through students' first three years in the NU system.

TSLC and COS students were more likely to enroll and persist in the NU system than control students, beginning with initial fall enrollment. This differential enrollment disrupted the baseline balance across groups, as shown in Appendix table A.1. However, balance is maintained between students in the TSLC and COS conditions, as shown in the top panel of Table 2. This balance is generally maintained when we limit the sample to students with a STEM major, as shown in the middle panel of Table 2, although there are more students of color in STEM in TSLC than are in COS. We limit our analyses to students in the TSLC and COS conditions and control for student characteristics. We further limit the sample to students with complete demographic information and major information (whether declared or undeclared). We define a STEM major as a student who has a recorded STEM major and who has at least one grade in a STEM course; students who ever meet these criteria are included in our analysis of the impact of participating in TSLC on STEM majors' achievement in STEM courses. We use the University of Nebraska system-provided cumulative GPA for our analysis of students' overall performance, and calculate students' STEM-specific cumulative GPA. Table 3 provides descriptive statistics for our primary analytic samples.

Data

Our data are primarily drawn from the University of Nebraska system, which provided students' ACT scores, semester-by-semester cumulative GPA, semester-by-semester declared major, semester-by-semester course enrollment, and individual course grades. We merge this data with data from the STBF, which includes students' expected family contribution (from their FAFSA), first-generation status, race/ethnicity, gender, high school GPA, ACT score, treatment status, intended campus at time of application, and cohort.

The University of Nebraska system includes three campuses and a medical center. Students who did not enroll at one of the three main campuses, either because they enrolled at a state college, community college, out-of-state institution, or did not enroll at all, are not observed in our data. Our estimates are conservative, as students may leave the NU system but still pursue a postsecondary credential, whether in STEM or not. Additionally, we were following cohorts of students randomized to TSLC and COS at specific campuses to see how their experience in that specific program affected their outcomes; students who transferred late (e.g. during or after their second year) are not necessarily retained in our sample.

Analytic Strategy

Once we restrict our analytic sample to students in the TSLC and COS conditions, our analysis is straightforward. First, we are interested in examining the effect of participating in TSLC on students' major declarations, overall and with an emphasis in STEM. We estimate a Probit model that expresses the likelihood a student will declare any major by the end of their second year on campus. This model is given in Equation (1):

$$(1)\quad \Pr(Y_{it} = 1|X) = \Phi(\beta_0 + \delta TSLC_i + \boldsymbol{\gamma X_i} + \boldsymbol{\tau} + \varepsilon_i)$$

In Equation (1), the outcome, Y_{it}, takes on the value of 1 if student has a declared major (e.g. is not classified as “undecided”, “undeclared”, “deciding”, or some other permutation of undeclared) by their fourth semester on campus (the end of their second year). Students are excluded if they have no major information. Our parameter of interest is δ, which captures the relationship between participating in TSLC and the likelihood a student will declare a major by the end of their second year. We include a vector of student characteristics ($\boldsymbol{X_i}$), including ACT score, high school GPA, expected family contribution, gender, race/ethnicity, and first-generation status. We include a vector of randomization strata fixed effects ($\boldsymbol{\tau}$), which account for differences in the probability of treatment across strata. ε_i is a stochastic error term.

We next look at the effect of participating in TSLC on the likelihood that a student will ever declare a STEM major while enrolled in the University of Nebraska system. We code students’ majors using the categories outlined in Perez-Felkner, Nix, and Thomas (2017). This model follows the same form as Equation (1), but the outcome (Y_{it}) is whether or not the student ever declares a STEM major in their first three years on campus (regardless of semester). We estimate heterogeneous effects for female students and students of color by interacting indicators for gender and race/ethnicity with the treatment indicator ($TSLC_i$).

Next, we are interested in estimating the impact of participating in TSLC students’ academic performance. We leverage the longitudinal nature of our data to estimate a random effects model relating, first, students’ overall cumulative GPA and, second, STEM majors’ cumulative GPA in their STEM courses to their participation in TSLC. The random effects model allows us to leverage the panel nature of our data while still estimating time-invariant student characteristics (such as treatment status). As treatment is randomized, the strict exogeneity assumption required for a causal interpretation of results from a random effects model is met. We estimate three separate effects using balanced panels: the effect of TSLC participation on students' first-year cumulative GPA among students who persisted through their first year; the effect of TSLC participation on students' second-year cumulative GPA among students who were enrolled in the NU system for semesters one through four; and, finally, the impact of participating in TSLC on students' third-year cumulative GPA for students who persisted through their third year. Our random effects model is given by Equation (2):

$$(2)\ \ Y_{it} = \beta_0 + \delta TSLC_i + \boldsymbol{y}\boldsymbol{X_i} + \alpha_i + \varepsilon_{it}$$

In Equation (2), our outcome, Y_{it}, is student *i*'s cumulative (or STEM-specific cumulative) GPA in semester *t*, $TSLC_i$ is an indicator for whether student *i* is in TSLC, $\boldsymbol{X_i}$ is a vector of student characteristics, including gender, race/ethnicity, first-generation status, ACT score, high school GPA, and expected family contribution, α_i is an individual effect, and ε_{it} is an error term clustered at the student level to account for the correlation of errors over time within individual. We include interaction terms to estimate heterogeneous effects of TSLC participation on female students' and students of color's academic achievement. We include all TSLC and COS students in the analysis when looking at cumulative GPA, and only those students majoring in STEM when looking at cumulative STEM GPA.

B. Qualitative Analyses

Context

During the first four years of the mixed-methods evaluation of the TSLC program, qualitative researchers engaged in a robust program of data collection, analysis, and member-checking (Hallett, Kezar, Kitchen et al., 2020). Credibility and trustworthiness were promoted through long-term engagement with the participants and in the field, member checking focus groups, and frequent debriefings with colleagues working on the larger mixed-methods project (Jones et al., 2006).

Sample

Students who participated in the qualitative portion of the study were purposely selected to represent a diverse group of students across race/ethnicity, gender, majors, and hometowns. Relative to the full CCTP population, students in the qualitative sample are more likely to be students of color (60% vs. 46%), female (68% vs. 65%), and first-generation (70% vs. 69%), although the differences are slight. Students who had and had not declared a STEM major were interviewed; it was common for students to be undecided/exploring or to change majors one or more times during the course of this longitudinal study.

Data

The primary data source for the current paper entailed more than 900 “digital diary” entries from 83 students: video blogs where students participating in the program discussed their experiences, responded to prompts, and shared their perceptions of the support they received from TSLC (Hallett, Kezar, Kitchen et al., 2020). Additionally, students were interviewed two to three times a semester for three years, with each interview lasting about 30 to 45 minutes. In the interviews, students responded to a range of questions related to their academic and major/career related experiences in TSLC. For instance, students were asked about their confidence in their major/career and to reflect on how the program influenced their major/degree path. Students were also asked to reflect on their experiences in the program’s proactive advising meetings and to describe how those meetings affected their confidence in their academic capabilities.

Analytic strategy

The research team analyzed the student interviews and constructed detailed, longitudinal student narratives (Reissman, 2008). These student narratives captured students’ experiences with the program’s academic and major/career-oriented support, and major turning points or epiphanies in their respective stories, and provide a useful aggregated summary of each student's first three years on campus. We used cross-case thematic analysis (Bartlett & Vavrus, 2017) of the 83 student narratives to identify themes and common patterns across students' longitudinal narratives related to students' major decision-making and academic success. We then analyzed how these themes and patterns related to our quantitative findings surrounding the likelihood that TSLC students would declare a STEM major and outperform their peers who did not receive the comprehensive support of the program. For the sake of space, this paper focuses on one student who was exploring a STEM major and whose narrative illustrates the major themes and patterns common across participants.

IV. Results

A. Quantitative Results

Major Declaration.

Table 4 presents the results of our Probit models estimating the impact of participating in TSLC on the likelihood a student will declare a major by the end of their second year and a STEM major during their first three years. As shown in column (1), there is no statistically significant relationship between the likelihood a student declares a major by the end of their second year and whether they participate in TSLC. Similarly, column (2) shows a positive, but statistically insignificant, difference in the likelihood that TSLC and COS students will declare a STEM major during their first three years.

Columns (3) and (4) show whether there are differential effects of participating in TSLC on the likelihood that female students and students of color, respectively, will declare a STEM major. Students of color in TSLC are significantly more likely to declare a STEM major during their first three years compared to COS students by about 18 percentage points ($p<.01$). Female students in TSLC are an estimated 10 percentage points more likely than female COS students to declare a STEM major, but the effect is not significant.

Academic Achievement.

Table 5 presents the results of our random effects models estimating the impact of participating in TSLC on achievement, for all students and specifically for STEM majors. Columns (1) through (3) show the effect of participating in TSLC on students' cumulative GPA. The top panel is restricted to students who were enrolled in the University of Nebraska system for at least their first two semesters. Among this group of students, we find that participating in TSLC leads to about a 0.27-point increase in first-year cumulative GPA ($p<.01$); this does not vary significantly by student sex or race/ethnicity. The middle panel is restricted to students enrolled in the University of Nebraska system for at least four semesters; here, we find that participating in TSLC leads to about a 0.10-point increase in second-year cumulative GPA ($p<.01$); again, we find no evidence that this varies by subgroup. Similarly, in the bottom panel, which is restricted to students enrolled in the University of Nebraska system for their first through sixth semester, participating in TSLC leads to a 0.07-point increase in cumulative GPA ($p<.05$) at the end of their first three years. There is some evidence that this effect might be stronger for female students ($\sigma = 0.11$; $p<.1$). This pattern of results suggests that participating in TSLC benefits all students, regardless of how long they remain enrolled in the University of Nebraska system, although the positive effects on GPA are largest in students' first year.

In column (4) we focus specifically on students who have declared a STEM major, and examine the impact of participating in TSLC on their achievement in STEM courses. Students in TSLC majoring in STEM outperform their COS peers by 0.30 GPA points in their first year ($p<.01$), 0.21 in their second year ($p<.01$), and 0.14 points in their third year ($p<.05$). The effects in years one and two represent a change of a letter grade in one class; for example, if a student taking four courses earned an A instead of a B in one course. The effect in year three is smaller: it is similar to what would happen if a student earned a B+ instead of a B in one class in a semester in which they were taking four three-credit classes.

We explore whether participating in TSLC has differential effects on STEM performance for female students and students of color majoring in a STEM field in columns (5) and (6), respectively. We find no evidence that participating in TSLC has a larger effect on achievement in STEM courses for either women or students of color.

B. *Qualitative Explanations*

Our qualitative analysis offers key explanations regarding the role of TSLC in shaping students' major decisions and academic achievement. Across students' longitudinal narratives, our findings indicate that TSLC takes a student-centered, proactive approach in providing academic support and major and career guidance. The program staff focus on providing support that is responsive to students' individual goals, needs, and experiences when helping students address academic challenges and make decisions about their majors. The program takes a proactive approach to academic support, reaching out early each semester to ask students to reflect on their academic performance and goals, connecting students to tutoring or study groups when they are experiencing academic challenges, and connecting students who are academically successful to enrichment opportunities such as undergraduate research.

We use a student narrative that illustrates these themes throughout our discussion. Bethany is a low-income, first-generation, female student who entered college with an interest in nursing. However, Bethany experienced a number of challenges in her required STEM classes. Her struggles with the coursework and waning interest in the subject matter caused her to doubt whether or not nursing, or any STEM field, was a good fit for her, or her ultimate career goal to "help other people." Her doubts were further exacerbated by a part-time job she had in the healthcare field, where she noticed her coworkers seemed "miserable" in their jobs.

Theme 1: Student-Centered Approach

Student interviews suggest that TSLC takes a student-centered focus, working with students individually to understand their personal interests, goals, experiences, and talents, and then working with them to make sense of their experiences in their major-related coursework. These one-on-one conversations may reaffirm that students' interests, goals, and talents are aligned with their choice of STEM major or prompt students to reconsider their choice of major and career path. Bethany's narrative illustrates how TSLC supported her as she grappled with whether or not to persist in STEM without promoting a particular decision. Instead, key actors in TSLC helped Bethany engage in exploration and sensemaking about her experiences and performance in her STEM classes, her impressions of her part-time job, and her personal career goals. For instance, she met with her TSLC mentor to discuss her low grades in her STEM courses and shared her doubts about staying in a science-heavy field like healthcare. She shared:

> [I] told her I've been like worried about my grades, I was confused about what I wanted to do major wise. She definitely reassured me – she laid out options that I could take, you know, like talking to an academic advisor, talking to a TSLC staff member, you know, looking more into majors that I'd be interested in. But just stuff like that. She was super helpful. She was super reassuring and it was very nice to have that.

Having support from her TSLC mentor was crucial for Bethany in determining whether it was a matter of seeking out additional support, like speaking to an academic advisor or TSLC staff, to help her succeed academically, or whether she should consider other options potentially better aligned with her interests and goals. The personalized, one-on-one support Bethany received illustrates the approach of TSLC, which focuses on each student's personal developmental trajectory and offers support and information to help the student decide what is the best fit for them, rather than encouraging pursuit of any particular degree or career. The program focused on helping Bethany make sense of her experiences and taking the time to explore options before finalizing her major/career. As a result of program support, Bethany was excited to think about career options that matched her goals and interests. She initially switched into a social science, only to later identify a different STEM degree she felt was suitable for her. She ultimately felt confident in her future because of support from TSLC.

Theme 2: Proactive Approach

The program's advising process proactively prompts students to engage in a structured reflection of their course grades, to consult with their instructors about their performance, and to discuss their academic progress with TSLC staff (Kitchen et al., 2020). In our exemplar narrative, Bethany recounts the importance of the proactive advising process and opportunities to meet with program staff advisors and course professors for her academic success:

> I think [the proactive advising grade check] matters, because it really opens a student's eyes as to like what their grades are mid-semester. And if you're doing good, then keep it up. But if you're not doing so well, then you need to hammer down and get those grades pumped up. And…it does give you a little connection with your professors if you really didn't have one before.

Proactive advising offers students structured opportunities to reflect on their grades and academic behaviors and to receive academic support and encouragement from program staff and professors early enough to make changes to their academic behaviors to reach their goals. As a result of the program's required proactive advising process, Bethany was "studying more, taking my classes seriously, asking questions to professors if I need, meeting with my professors." Proactive advising may be a key mechanism by which TSLC boosts students' academic achievement.

Bethany's narrative illustrates the student-centered, proactive approach TSLC takes in supporting students in STEM that we found across student narratives. Her story also illustrates some of the important elements of the program that commonly shaped students' major/career decision making and promoted their academic achievement. These experiences offer plausible explanations for why the TSLC program does not appear to have an impact on whether students declare a STEM major, but does have an impact on students' academic achievement, overall and in STEM courses. Because TSLC takes a student-centered approach, outcomes vary by students' individual needs, goals, and experiences before and during college. In the quest to encourage students to choose and/or persist in STEM fields, it is critical to understand students' goals and to help engage students in sense-making to determine whether it is in their best interest to pursue a STEM degree.

V. Discussion and conclusion

This paper examined the impact of participating in a comprehensive college transition program on students' major decisions and academic performance. We find no evidence to suggest that students in TSLC are more likely to declare a major by the end of their second year or to declare a STEM major during their first three years. This may indicate that the program is helping students find the major that is the best fit for them, given their interests, background, and skills, rather than rushing students or steering students towards particular majors. However, we do find that students of color in TSLC are significantly more likely to declare a STEM major than their peers in COS. Providing students with individualized, comprehensive support may have the potential to improve equity in STEM majors.

While TSLC is not pushing students towards STEM fields, it is ensuring that all students, including those majoring in STEM, are successful in their courses. We find that TSLC students outperform COS students overall, and that STEM majors in TSLC outperform COS STEM majors in STEM courses. We do not find differential effects for women or students of color. This suggests that programs and institutions interested in promoting equitable outcomes in STEM should think critically about what difficulties students face, whether it is in accessing STEM majors, achieving at high levels in STEM courses, completing STEM degrees, or securing employment in a STEM field, and customizing the support they provide accordingly.

Evaluations of CCTPs typically focus on the impact of such programs on academic outcomes, particularly degree completion. We show that CCTP participation may also have other important spillover effects for current policy concerns. Understanding how CCTP participation affects students' major decisions, career aspirations, and longer-term employment outcomes could have broad implications for policy and practice.

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Tables and Figures

Figure 1

Timeline of Support from TSLC

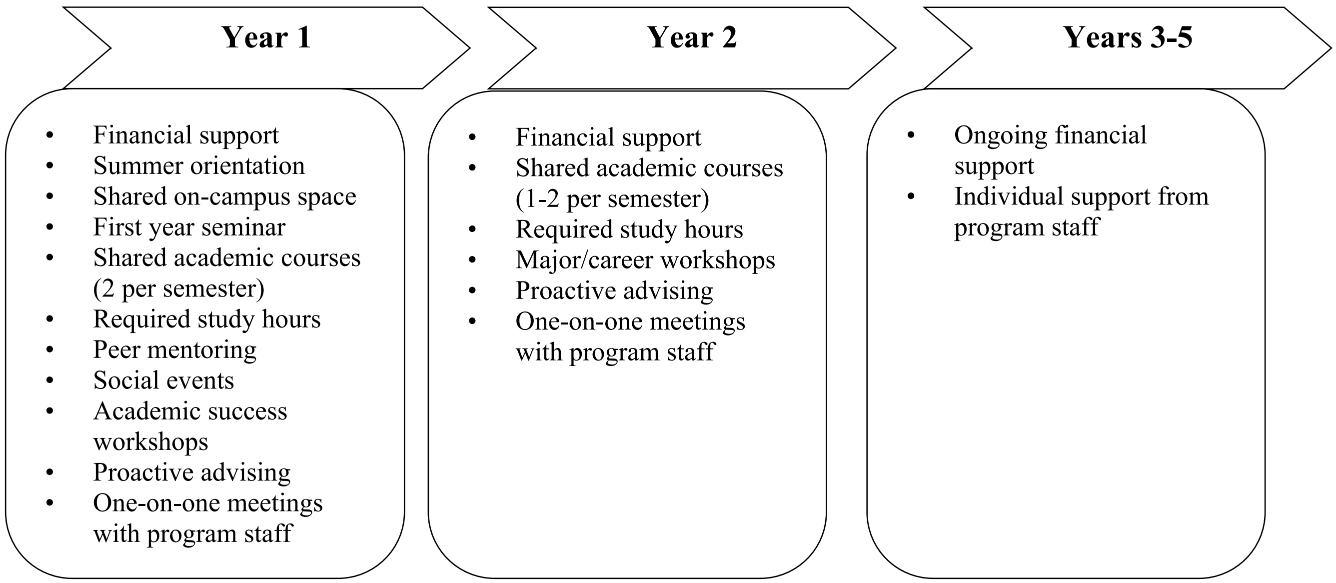

Table 1

Enrollment in NU system over time

	RCT Sample	Analytic Frame	Students Enrolled in NU System: Through Year 1	% of Analytic Frame	Through Year 2	% of Analytic Frame	Through Year 3	% of Analytic Frame
All Majors								
TSLC	617	605	597	98.68%	539	89.09%	496	81.98%
COS	379	370	360	97.30%	299	80.81%	268	72.43%
TSLC + COS	*996*	*975*	*957*	*98.15%*	*838*	*85.95%*	*764*	*78.36%*
STEM Majors								
TSLC	326	307	305	99.35%	284	92.51%	264	85.99%
COS	179	169	167	98.82%	145	85.80%	130	76.92%
TSLC + COS	*505*	*476*	*472*	*99.16%*	*429*	*90.13%*	*394*	*82.77%*

Note. RCT sample excludes must-fund students. RCT sample restricted to students who targeted a University of Nebraska (NU) campus on their scholarship application. Analytic frame restricted to students who have complete demographic information (ACT score, high school GPA, EFC, gender, race/ethnicity, and first-generation status) and who have a recorded major at some point during their first four semesters. Students are defined as persisting through year one if they are enrolled in the NU system for their first and second semesters, through year two if they are enrolled in the NU system for semesters one through four, and through year three if they are enrolled in the NU system for semesters one through six.

Table 2

Baseline Balance between RCT-TSLC and COS Conditions

		(1)	(2)	(3)	(4)	(5)	(6)
		ACT Score	High School GPA	EFC	Female Student	Student of Color	First-Generation
All Majors							
Ever Enrolled	TSLC v. COS	-0.152	0.037	-91.995	0.009	0.040	0.035
		(0.283)	(0.027)	(196.362)	(0.032)	(0.031)	(0.030)
	Observations	*975*	*975*	*975*	*975*	*975*	*975*
Persist Year 1	TSLC v. COS	-0.129	0.044	-101.378	0.008	0.041	0.038
		(0.288)	(0.028)	(199.062)	(0.032)	(0.032)	(0.030)
	Observations	*957*	*957*	*957*	*957*	*957*	*957*
Persist Year 2	TSLC v. COS	-0.312	0.028	-182.318	0.007	0.049	0.041
		(0.312)	(0.029)	(218.349)	(0.035)	(0.034)	(0.033)
	Observations	*838*	*838*	*838*	*838*	*838*	*838*
Persist Year 3	TSLC v. COS	-0.512	0.011	-228.724	0.006	0.071*	0.048
		(0.324)	(0.030)	(230.634)	(0.037)	(0.036)	(0.035)
	Observations	*764*	*764*	*764*	*764*	*764*	*764*
STEM Majors							
Ever Enrolled	TSLC v. COS	-0.289	0.050	35.182	0.069	0.131***	0.018
		(0.420)	(0.039)	(277.385)	(0.046)	(0.046)	(0.043)
	Observations	*476*	*476*	*476*	*476*	*476*	*476*
Persist Year 1	TSLC v. COS	-0.257	0.056	54.480	0.060	0.127***	0.019
		(0.424)	(0.039)	(278.787)	(0.046)	(0.046)	(0.044)
	Observations	*472*	*472*	*472*	*472*	*472*	*472*
Persist Year 2	TSLC v. COS	-0.489	0.040	72.067	0.062	0.124**	0.020
		(0.452)	(0.041)	(300.066)	(0.049)	(0.049)	(0.047)
	Observations	*429*	*429*	*429*	*429*	*429*	*429*
Persist Year 3	TSLC v. COS	-0.579	0.040	65.080	0.073	0.148***	0.012
		(0.470)	(0.042)	(318.004)	(0.052)	(0.051)	(0.050)
	Observations	394	394	394	394	394	394

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

Note. Standard errors in parentheses. Models control for randomization strata (intended campus by cohort) fixed effects. Sample excludes must-fund and no-fund students. Sample restricted to students who targeted a University of Nebraska system school on their scholarship application, who have complete demographic information, and who have major information (declared or undeclared) during their first two years. STEM majors are students who have declared a STEM major and have at least one recorded grade in a STEM course.

Table 3

Student Characteristics, Analytic Samples

	N	% Students of Color	% Female	% First Gen	Avg. EFC	Avg. ACT	Avg. HS GPA
All Majors							
Ever Enrolled	975	43.69%	62.67%	70.26%	$2686.83	22.05	3.44
Persist 1 Yr.	957	43.78%	62.70%	70.32%	$2713.54	22.07	3.45
Persist 2 Yrs.	838	42.84%	62.65%	68.74%	$2824.29	22.32	3.49
Persist 3 Yrs.	764	41.75%	62.70%	67.28%	$2845.15	22.44	3.51
STEM Majors							
Ever Enrolled	476	42..02%	65.76%	70.80%	$2631.73	22.71	3.51
Persist 1 Yr.	472	42.16%	65.89%	70.97%	$2642.06	22.71	3.51
Persist 2 Yrs.	429	42.66%	65.27%	69.70%	$2711.39	22.89	3.53
Persist 3 Yrs.	394	40.86%	64.72%	68.02%	$2762.60	23.09	3.55

Note. Sample excludes must-fund and no-fund students. Sample restricted to students who targeted a University of Nebraska system school on their scholarship application, who have complete demographic information, and who have major information (declared or undeclared) during their first two years. STEM majors are students who have declared a STEM major and have at least one recorded grade in a STEM course.

Table 4

Effect of TSLC Participation on Major Declaration, Probit, Marginal Effects

	(1) Declare Major by Year 2	(2) Ever Declare STEM Major	(3) STEM Major-Gender	(4) STEM Major-Race
TSLC	0.005	0.039	-0.023	-0.035
	(0.024)	(0.032)	(0.053)	(0.042)
ACT Score	0.011***	0.015***	0.015***	0.015***
	(0.004)	(0.005)	(0.005)	(0.005)
HS GPA	0.075**	0.098**	0.095**	0.094**
	(0.033)	(0.045)	(0.045)	(0.045)
EFC	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Female Student	0.026	0.082**	0.020	0.083**
	(0.025)	(0.033)	(0.053)	(0.033)
Student of Color	0.030	0.043	0.042	-0.067
	(0.029)	(0.038)	(0.038)	(0.055)
First-Generation	-0.033	0.059	0.057	0.057
	(0.029)	(0.037)	(0.037)	(0.037)
TSLC x Female Student			0.099	
			(0.066)	
TSLC x Student of Color				0.177***
				(0.064)
Observations	975	975	975	975

Note. Standard errors in parenthesis. Models include randomization strata fixed effects. Sample excludes must-fund, no-fund, and control students. Sample restricted to students who targeted a University of Nebraska system school on their scholarship application, have complete demographic information, and who have recorded major information (declared or undeclared). Having a STEM major has two components: 1) having a recorded STEM major and 2) having at least one recorded grade in a STEM course.
*p<.1, **p<.05, ***p<.01

Table 5

Impact of Participating in TSLC on Academic Performance

	Cumulative GPA (All Majors)			STEM GPA (STEM Majors Only)		
	(1)	(2)	(3)	(4)	(5)	(6)
Persist Through Year 1						
TSLC	0.255***	0.234***	0.210***	0.310***	0.346**	0.286***
	(0.050)	(0.083)	(0.061)	(0.089)	(0.148)	(0.106)
TSLC x Female		0.033			-0.055	
		(0.104)			(0.185)	
TSLC x Student of Color			0.105			0.064
			(0.104)			(0.191)
Observations	1,905	1,905	1,905	929	929	929
Number of students	957	957	957	472	472	472
Persist Through Year 2						
TSLC	0.099***	0.052	0.072*	0.205***	0.189	0.168*
	(0.034)	(0.055)	(0.041)	(0.077)	(0.127)	(0.089)
TSLC x Female		0.075			0.025	
		(0.069)			(0.160)	
TSLC x Student of Color			0.067			0.097
			(0.072)			(0.172)
Observations	3,313	3,313	3,313	1,581	1,581	1,581
Number of students	838	838	838	429	429	429
Persist Through Year 3						
TSLC	0.066**	-0.004	0.078**	0.144**	0.133	0.163*
	(0.030)	(0.050)	(0.039)	(0.074)	(0.119)	(0.085)
TSLC x Female		0.111*			0.019	
		(0.063)			(0.152)	
TSLC x Student of Color			-0.031			-0.053
			(0.063)			(0.169)
Observations	4,560	4,560	4,560	2,054	2,054	2,054
Number of students	764	764	764	394	394	394

Note. Standard errors clustered by student. Models control for ACT score, high school GPA, expected family contribution, sex, race/ethnicity, and randomization strata. Sample excludes must-fund, no-fund, and control students, students with missing demographic information, and students with no major information. STEM achievement sample (columns 4-6) restricted to students with a STEM major; students must have declared a STEM major and earned at least one grade in a STEM course. Students are defined as persisting through year one if they are enrolled in the NU system for their first and second semesters, through year two if they are enrolled in the NU system for semesters one through four, and through year three if they are enrolled in the NU system for semesters one through six.

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

Appendix

Table A1

Baseline Balance between RCT-TSLC, COS, and Control Conditions

	(1) ACT Score	(2) High School GPA	(3) EFC	(4) Female Student	(5) Student of Color	(6) First-Generation
TSLC v. Control	-0.624***	-0.034	-84.904	0.009	0.067***	0.066***
	(0.220)	(0.021)	(152.299)	(0.025)	(0.024)	(0.024)
COS v. Control	-0.489*	-0.071***	0.990	-0.002	0.028	0.030
	(0.260)	(0.025)	(180.411)	(0.029)	(0.029)	(0.028)
Observations	*2,128*	*2,128*	*2,128*	*2,128*	*2,128*	*2,128*

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

Note. Standard errors in parentheses. Models control for randomization strata (intended campus by cohort) fixed effects. Sample excludes must-fund and no-fund students. Sample restricted to students who targeted a University of Nebraska system school on their scholarship application, who have complete demographic information, and who have major information (declared or undeclared) during their first two years.