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RESEARCH ARTICLE

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Comparison of transfer shock and graduation rates across engineering transfer student populations

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Abstract

Background: Increasing the persistence of engineering transfer students can help meet the US national priority of increasing the number of engineering graduates. Many transfer students experience a decrease in their grade point average (GPA) at their receiving institution, known as transfer shock, which can lead to them leaving the institution. This GPA decrease is found to be more prevalent in engineering transfer students.

Purpose/Hypothesis: The purpose of this study is to analyze a single institutional dataset to determine when transfer shock occurs, how it differs among engineering transfer student subgroups, and if transfer shock is a predictor of graduation within 4 years in engineering.

Design/Method: A 10-year dataset with 789 engineering transfer students was used in this study, and the engineering transfer students were split into four subgroups. Multiple statistical analyses were conducted, including Welch's *F*-test, chi-square, and logistic regression, to understand differences in transfer shock during the first three terms of enrollment as well as 4-year graduation rates among each subgroup.

Results: Transfer shock extends through the first three post-transfer terms, resulting in transfer norming. The engineering transfer student subgroups experience different levels of transfer norming; however, the subgroups were not predictors of graduation. The predictors were the transfer GPA and the transfer norming in the first three post-transfer terms of enrollment.

Conclusions: Engineering transfer students are not a homogeneous population; there are key differences between lateral and vertical transfer students. More strategic, longitudinal programming and decision-making should be considered by institutions.

KEYWORDS
persistence, regression, transfer student

1 | INTRODUCTION

A recent report from the Western Interstate Commission for Higher Education (WICHE) predicts there will be a decline in the number of high school graduates over the next decade (Bransberger et al., 2020). As the total number of high school graduates declines, the total number of students entering higher education will decline. The demand for bachelor's degree graduates is steadily increasing; however, the decline of high school graduates will decrease the supply of bachelor's degree-seeking students. To meet the demand for bachelor's degree graduates, higher education and enrollment management must begin to think even more strategically, and broadly, about student persistence.

Pascarella et al. (1986) define persistence as actively working toward a bachelor's degree within 9 years. For nearly 30 years, researchers and institutions have focused primarily on first-time in college (FTIC) students at a 4-year institution, with some attention also given to the persistence of students in 2-year institutions. The focus on FTIC students should not be lost; however, the higher education community must also better understand transfer students. Transfer students are defined as students attending more than one institution on their route to a bachelor's degree and represent a growing trend in the United States (Brawner & Mobley, 2016; Habley et al., 2012). From 2012 to 2017, the National Student Clearinghouse (NSC) reported a 2% increase in vertical transfers, which are students who begin at a 2-year institution and transfer to a 4-year institution (Shapiro et al., 2018). NSC also reports a 4% increase in lateral transfers, which are students who begin at a 4-year institution and transfer to another 4-year institution (Shapiro et al., 2018). While persistence at a particular institution may not be possible for some students for a variety of reasons, there are still opportunities for students to transition to another institution and complete their bachelor's degree. Supporting students who elect to transfer is an important priority that institutions must consider in their strategic enrollment management planning as we work toward our national goals.

Transfer students are also found to have greater levels of racial, ethnic, and socioeconomic diversity (Tobolowsky & Cox, 2012). Increasing diversity in engineering is as important as increasing the number of engineering graduates. The gains from increasing diversity include increasing the intellectual capacity of the US STEM workforce, which leads to enhancing US global competitiveness and national security (Long & Mejia, 2016).

Student persistence specifically within engineering has received much attention over the last several decades. However, the American Society for Engineering Education (ASEE) reports that graduation rates of engineering students have minimally changed (ASEE, 2016). The ASEE report is based on FTIC students; information is not collected on a national level for engineering transfer students. With fewer students expected to enter engineering programs, and more students completing a transfer, understanding engineering transfer student persistence should also be a focus for engineering education.

Transfer shock refers to a decrease in grade point average (GPA) that students commonly experience when transitioning to a new institution (Hills, 1965). The existing literature on transfer students discusses the increased prevalence of transfer shock in engineering transfer students (Anderson-Rowland, 2011). Additionally, Lakin and Cardenas Elliott (2016) demonstrated transfer shock was even more common in engineering transfer students completing a vertical transfer. Researchers find transfer shock to be a strong predictor of transfer students falling below a 2.0 overall GPA and being placed on academic probation after their first post-transfer term (Graham & Dallam, 1986; Lakin & Cardenas Elliott, 2016). Researchers also find transfer shock is a strong predictor of transfer students leaving the institution before graduation (Glass & Harrington, 2002; Ishitani, 2008).

This paper analyses a 10-year institutional dataset of engineering transfer students at a large public southeastern research university where transfer students represent approximately 14% of the university's incoming engineering students each year. The analysis provides comparisons of transfer shock across three semesters and four engineering transfer student subgroups as well as if transfer shock is a predictor of 4-year graduation rates in engineering. The graduation rates for FTIC and transfer students at the institution are very high compared with national benchmarks. This study aims to determine how the findings can inform other institutions of practical recommendations for increasing the persistence of engineering transfer students.

2 | BACKGROUND

The engineering transfer student population gained traction in the literature in the 2000s. Early research focused on student factors; however, there has been a noticeable shift in the research in the last decade. Researchers began to also focus on identifying institutional practices and understanding the role of the receiving institution as a responsible party in the graduation of transfer students. Smith and Van Aken (2020) identified key limitations in the existing literature on engineering transfer student persistence. First, the literature primarily focuses on students completing a vertical transfer. However, the 2018 NSC report shows students are completing lateral transfers at a rate nearly equal to vertical transfers (Shapiro et al., 2018). Additionally, the literature primarily reviews academic performance during the first post-transfer term. Smith and Van Aken (2020) indicate academic performance after the first post-transfer term should be further explored to identify additional ways to increase graduation rates for engineering transfer students. Exploration of academic performance of transfer students beyond the first post-transfer term also aligns with the literature supporting a continuous review of FTIC students past their first year of enrollment (McBurnie et al., 2012; Wilder, 1993) and can lead to additional insights on the experiences of engineering transfer students as they progress through the engineering curriculum.

This study is grounded in Tinto's (1993) student integration model (SIM), which is a well-regarded persistence framework that has continued to be modified and validated by researchers since Tinto shared his initial framework in 1975. Tinto's SIM posits that students' academic and social integration influences their persistence at the institution (Tinto, 1993). They argued that for students to persist, they must have access to programming that supports their needs, focuses on social and academic integration, and is designed for the whole population (Tinto, 1993). In addition to these institutional priorities needed to encourage persistence, Tinto states student characteristics also influence persistence and include pre-entry attributes, academic performance, and family background (Tinto, 1993).

There are limitations to the model that have been well documented, including the framework's strong dependence on traditional 4-year residential campuses whose primary student population are White students (Bean & Metzner, 1985; Grayson & Grayson, 2003). Despite these limitations, Tinto's SIM is the most widely cited retention theory (Chrysikos et al., 2017). The specific variables within the model and their interactions can be disputed, but the overarching framework is sound (Chrysikos et al., 2017).

In Tinto's model, several interacting components influence a student's academic and social integration. Understanding the full breadth of Tinto's components is outside the scope of this research. Our work does not include components of the social integration concept but rather is nested in the academic integration component of the model and considers how specific pre-entry attributes may influence students' formal academic system, particularly their academic performance.

Smith and Van Aken (2020) as well as Lee and Schneider (2016) cited concerns with Tinto's model when applying it to transfer student persistence. Specifically, Tinto's model refers to high school preparation as part of the pre-entry characteristics of a student as well as academic performance. In our study, Tinto's classification of prior schooling is evaluated and operationalized as pre-transfer academics and is measured as transfer GPA and transfer student subgroup. For academic performance, this study measures the difference between the students' GPA at their sending institution and their term GPA at the receiving institution in their first three terms of enrollment to better characterize their transfer shock. These adjustments are based on Smith and Van Aken's (2020) recommendations for the adaptation of Tinto's model.

Tinto's model also includes student demographics, which we have included in our analysis as well. Table 1 provides context for how the demographics of engineering transfer students differ from that of FTIC students at the institution in this study. Tobolowsky and Cox (2012) indicate there is a greater level of diversity in the transfer student population, which is the case with the dataset used in this study as well. The transfer population has a slightly higher percentage of Black or African American, Hispanic/Latinx, and first-generation students. However, the FTIC population has a higher percentage of females.

3 | RESEARCH OBJECTIVES

Retention of engineering students is a well-researched area, but the focus has primarily been on FTIC students. The research on transfer students is growing but mainly focuses on increasing access through transfer pathways from a 2-year institution to a 4-year institution. Our research analyses a single-institution longitudinal dataset to demonstrate similarities and differences between transfer shock and graduation rates for engineering transfer students. This study explores four research questions related to these topics.

1. Does transfer shock extend beyond the first post-transfer term?
2. Do subgroups of engineering transfer students experience differing levels of transfer shock?
3. Are there variations in 4-year graduation rates across subgroups of engineering transfer students?
4. Is transfer shock a predictor of 4-year graduation rates within engineering?

TABLE 1 Student demographics

	Transfer		FTIC	
Demographics	***n***	**%**	***n***	**%**
Race/ethnicity				
American Indian or Alaska Native	–	–	–	–
Asian	105	13	450	8
Black or African American	26	3	131	2
Hispanic (of any race)	46	6	301	5
Nonresident alien	69	9	277	5
Not reported	31	4	119	2
Two or more races	33	4	208	3
White	478	61	4470	75
Gender				
Male	704	89	4788	80
Female	83	11	1177	20
Not reported	–	–		
First generation	224	28	658	11

Abbreviation: FTIC, first-time in college.

Several decisions were made related to the research questions. To address student transitions, transfer shock was selected as it is found in much of the literature related to transfer student persistence (Smith & Van Aken, 2020; Tobolowsky & Cox, 2012). Typically, transfer shock is referred to as happening in the first term of enrollment. Smith and Van Aken (2020) posit academic performance beyond the first term should be considered as researchers look further into transfer student persistence. Based on a review of the available data, over half of the engineering transfer students who do not persist will leave after the start of their second post-transfer year. Using the beginning of their second post-transfer year as a milestone, we wanted to investigate students who persist after their first post-transfer year and determine how their next academic term may relate to their eventual graduation in engineering. Therefore, we expanded the notion of transfer shock through the first three post-transfer terms.

When looking at differences among student subgroups, the literature supports differences among vertical transfer students with an associate degree and vertical transfer students without an associate degree (Darrow & Laanan, 2012; Hutton & Panter, 2015). Our initial analysis was focused on vertical transfer students with an associate degree and vertical transfer students without an associate degree. However, as the data were analyzed, it became clear there was a sizeable population of lateral transfer students, both in-state and out-of-state. Additionally, Cosentino et al. (2014) demonstrated in-state status was a significant variable when modeling the graduation of engineering transfer students. Smith and Van Aken (2020) also recommend considering the difference between vertical and lateral transfer students. Therefore, we decided to use four distinct subgroups for the analysis, as described in Table 2. Lastly, a 4-year graduation rate is used for comparison, which aligns with findings by Ohland et al. (2009), who indicate a 4-year persistence rate is highly predictive of 6-year graduation rates.

Seventy-four percent of the lateral in-state (LIS) students are from five sending institutions, and four of the five institutions are also large public institutions with an engineering program. One of the institutions has a much smaller enrollment and does not have an engineering program, but it is geographically close to the institution in this study. The (lateral out-of-state) LOS students came from a much broader set of institutions, with 75% of the sending institutions only having one student attend the receiving institution. The VAD students were all from community colleges within the same state. Of the VNAD students, there were some from out-of-state community colleges; however, 91% of the VNAD students were from a community college within the same state.

4 | METHODS

Data on all transfer students enrolled at the institution from 2009 to 2018 were provided by the University Registrar's Office and the Office of Institutional Research. These datasets were merged for a comprehensive historical dataset that

TABLE 2 Overview of engineering transfer student subgroups

Transfer student subgroup	Abbreviation	Number of students	Average number of transfer credits	Number of vertical institutions	Number of lateral institutions
Lateral in-state	LIS	127	49	9	18
Lateral out-of-state	LOS	102	42	6	76
Vertical with an associate degree	VAD	95	65	16	1
Vertical with no associate degree	VNAD	465	54	44	31

included student demographics, admissions information, transfer credits and institutions, and institutional enrollment data. The institutional enrollment data provided a history of the student's progression through the institution including their major each term as well as their graduation major and date when applicable. Only students admitted as engineering transfer students were considered for the analysis, resulting in 2589 students in the initial dataset. However, the analysis considers graduation rates in 4 years; therefore, only cohorts admitted between 2009 and 2014 could be used, which decreased the total students to 1233.

Several variables were calculated or determined and added to the dataset before analysis. First, each student was categorized by their engineering transfer student subgroup, which was determined by reviewing the students' sending institution and their transfer degree tag. There were 419 students (53%) who attended multiple sending institutions that ranged from two institutions to seven. For the students attending multiple institutions, the sending institution used to determine the subgroup was selected by using the sending institution providing the highest number of credit hours for that student. The decision to use the highest number of credit hours was based on findings from Shayevich et al. (2008) who indicated the number of transferrable credits is a predictor of transfer student success. Each sending institution was identified as a 2-year or 4-year institution. Students who attended a 2-year institution with a noted associate degree were coded as VAD (vertical transfer student with associate degree). Students with no associate degree were coded as VNAD (vertical transfer student with no associate degree). Any sending institution not identified as a 2-year institution was reviewed for lateral transfer status. Students from sending institutions located in the same state as the receiving institution were coded as LIS (lateral in-state transfer student), and lateral transfer students from out-of-state were coded as LOS (lateral out-of-state transfer student).

The second variable was created through a multistep approach used to determine each student's graduation status. The initial step included determining if the student graduated from engineering and how many years were needed to complete their degree. For students who did not graduate with an engineering major, the historical dataset was used to determine if they continued enrollment in engineering the past 4 years or stopped before the fourth year, with appropriate coding for each. In this study, there was no differentiation between a student leaving engineering or leaving the institution; both were coded as "did not graduate in engineering."

The next step added three variables by calculating the term GPA for each student's first, second, and third post-transfer term of enrollment. Summer enrollment was not included; thus, only fall and spring terms with 12 or more credits hours were considered a term. Finally, three more variables were added to compare the calculated term GPA to the GPA students had at their sending institution at the time of application.

- Transfer shock measurement 1 (TSM 1): first post-transfer term GPA minus transfer GPA
- Transfer shock measurement 2 (TSM 2): second post-transfer term GPA minus transfer GPA
- Transfer shock measurement 3 (TSM 3): third post-transfer term GPA minus transfer GPA

The transfer shock measurement (TSM) variables measured transfer shock in the first three post-transfer terms. TSM variables were not able to be computed for 77 students because the students were not enrolled in 12 or more credit hours in their first post-transfer term of enrollment, and an additional 367 did not have a transfer GPA available, resulting in 444 students being excluded. The final dataset included 789 students.

Statistical analyses were conducted using R (R Core Team, 2017) to investigate the differences in transfer shock, 4-year graduation rates among the engineering transfer student subgroups, and if transfer shock is a predictor of 4-year graduation rates. Though the assumption of normality due to sample size and the central limit theorem suggests parametric tests could be warranted (Field et al., 2012), analysis within each subgroup revealed that some subgroups showed skew and kurtosis values that would otherwise suggest exploring nonparametric equivalents. Additionally, Bartlett's test indicated heterogeneity of variance; therefore, we ran both parametric and nonparametric tests (Snedecor & Cochran, 1989). For the parametric tests, we used Welch's *F*-test, which is a more robust parametric test in these instances (Field et al., 2012). We followed that with a post hoc analysis and used paired *t*-tests with adjusted *p* values for family-wise error rates using Holm correction for the traditional Bonferroni method (Holm, 1979). Cohen's *d* was also calculated for effect size (Cohen, 1988). For the nonparametric tests, we use Kruskal–Wallis with a Wilcoxon post hoc test (Field et al., 2012). The omnibus tests (i.e., Welch's *F*-test and Kruskal–Wallis) were in near agreement on statistically significant findings for all variables. The criteria for significance in all tests were alpha = .05. The post hoc tests for each were nearly in full agreement, with one borderline case that was slightly above .05 on one test and slightly below .05 on another. The nonparametric tests are reported; however, since test results had similar findings, means and standard deviations are also reported as they are more helpful to the reader than reporting mean ranks from nonparametric testing.

A chi-square test of independence was used to understand the difference among the frequencies of students across the subgroups and 4-year graduation rates, including Cramer's *V* for effect size (Cohen, 1988). Logistic regression was then used to explore if transfer shock is a predictor of graduation and was selected based on the ability to incorporate transfer shock measurements as continuous independent variables and a binary dependent variable of graduated or did not graduate (Tabachnick & Fidell, 2013). Lastly, group analysis was conducted to identify tiered TSM ranges and determine their influence on graduation rates.

5 | RESULTS

5.1 | Descriptive statistics

The transfer GPA and term GPA in the first three post-transfer terms were reviewed across the subgroups to understand if there were apparent differences. Figure 1 shows the transfer GPAs for each subgroup have very similar distributions; however, there is variation in the term GPAs.

Lateral transfer students have higher GPAs in the first post-transfer term than vertical transfer students. The lateral transfer students have the largest degree of change in the first three terms. The second post-transfer term has the lowest GPAs for each transfer subgroup, indicating students are not only experiencing transfer shock in their first post-transfer term of enrollment but that this phenomenon extends into subsequent terms.

Table 3 provides a summary of the mean and standard deviation for each transfer shock measurement across the subgroups. Negative values indicate the mean GPA in that term was below the transfer GPA. On average, students in all subgroups performed below their transfer GPA in each of the first three terms of post-transfer enrollment.

These findings indicate that transfer shock is not a singular occurrence that happens in the first post-transfer term but rather a phenomenon that continues into the second and third post-transfer terms of enrollment. Additionally, the standard deviations are high, indicating there is a significant amount of variation in student performance. The second post-transfer term has the highest level of transfer shock of the first three terms, which further supports transfer shock continuing past the first post-transfer term. The lateral transfer students appear to perform better in all three post-transfer terms, with the least amount of transfer shock in the first post-transfer term, a large drop in the second post-transfer term, and improvement in the third post-transfer term. The VAD students perform worse in the first post-transfer term than the lateral students but better than VNAD students. The second post-transfer term for VAD students declines; however, by the third post-transfer term, the VAD students performed similar to their first post-transfer term. The VNAD students have the most transfer shock in the first post-transfer term and experience very little variation in the subsequent terms compared with the VAD and lateral transfers.

The mean transfer GPA for all students in this study was a 3.5, with little variation among the subgroups. The decline in post-transfer GPAs compared with the transfer GPA could be due to students acclimating to the receiving institution, or the decline could be indicative of different performance standards at the sending institutions. There may also be a combination of the acclimation process and different performance standards that lead to a decline in post-transfer GPAs for engineering transfer students.

A Spearman correlation analysis was also conducted on the TSM values to determine the extent they present the same students (see Table 4). There are moderate, positive correlations among each of the measurements (Field et al., 2012). Specifically, as transfer shock in one term increases, transfer shock in the next term tends to increase as well.

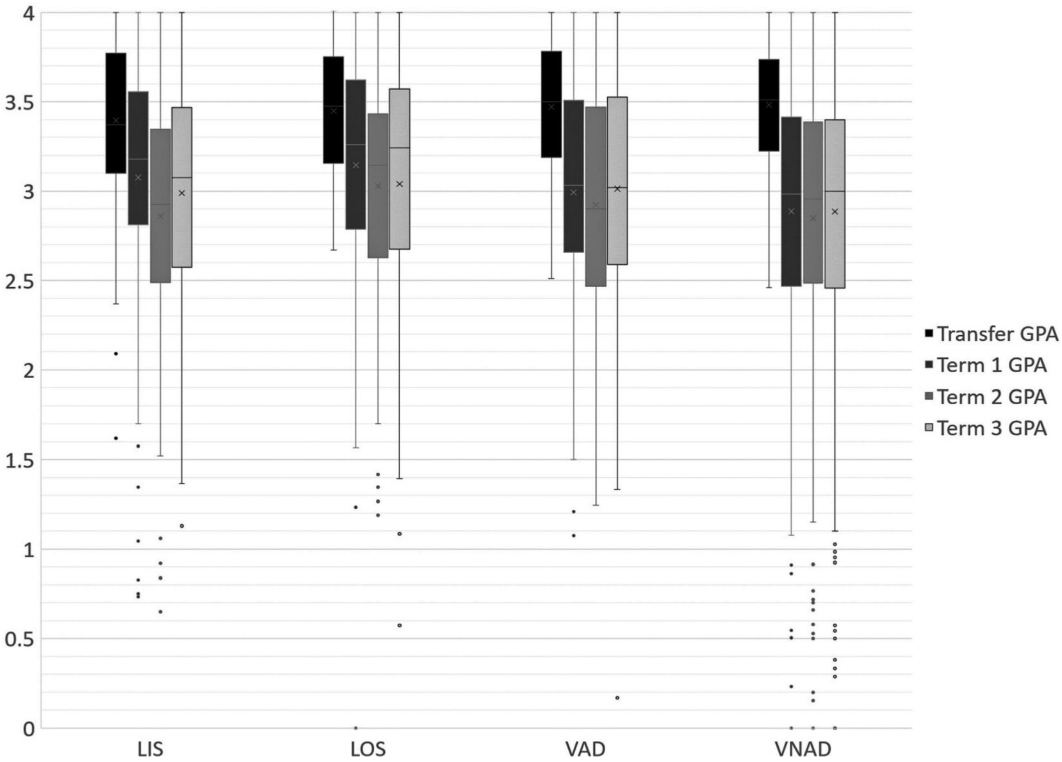

FIGURE 1 Box plots of transfer GPA and term GPAs by transfer student subgroup. GPA, grade point average; LIS, lateral in-state transfer student; LOS, lateral out-of-state transfer student; VAD, vertical transfer student with associate degree; VNAD, vertical transfer student without associate degree

TABLE 3 Transfer GPA and transfer shock measurement (TSM) mean and standard deviation (SD) for each transfer student subgroup for the first three post-transfer semesters

Transfer student subgroup	Transfer GPA (SD)	TSM 1 mean (SD)	TSM 2 mean (SD)	TSM 3 mean (SD)
LIS	3.39 (0.44)	−0.32 (0.70)	−0.53 (0.70)	−0.41 (0.69)
LOS	3.45 (0.36)	−0.30 (0.70)	−0.42 (0.64)	−0.41 (0.72)
VAD	3.47 (0.40)	−0.48 (0.58)	−0.55 (0.69)	−0.46 (0.62)
VNAD	3.48 (0.33)	−0.60 (0.63)	−0.63 (0.71)	−0.60 (0.72)
All subgroups	3.46 (0.36)	−0.50 (0.66)	−0.58 (70)	−0.53 (71)

Abbreviations: GPA, grade point average; LIS, lateral in-state transfer student; LOS, lateral out-of-state transfer student; VAD, vertical transfer student with an associate degree; VNAD, vertical transfer student without an associate degree.

TABLE 4 Spearman correlation analysis for transfer shock measurement (TSM) variables

	TSM 1	TSM 2	TSM 3
TSM 1	1	0.45	0.41
TSM 2	0.45	1	0.43
TSM 3	0.41	0.43	1

5.2 | Welch's *F*-test

A Welch's *F*-test was conducted on each transfer shock measurement to determine if there are significant differences in transfer shock across the subgroups, as demonstrated in Table 5. Significant differences were found for all three transfer shock measurements, indicating that the differences are likely due to the engineering transfer student subgroup.

TABLE 5 Welch's *F*-test results for transfer shock measurement (TSM) variables

	TSM 1	TSM 2	TSM 3
Statistic	8.948	3.189	3.978
df1	3	3	3
df2	228.552	234.017	235.883
Significance	1.252e−05	0.024	0.009

TABLE 6 Percentage of transfer students who graduated in engineering in 4 years for each transfer student subgroup

Transfer student subgroup	*N*	Graduated in engineering within 4 years
Lateral in-state (LIS)	127	84%
Lateral out-of-state (LOS)	102	81%
Vertical transfer student with an associate degree (VAD)	95	78%
Vertical transfer student without an associate degree (VNAD)	465	72%
All transfer students	789	76%

Post hoc tests indicate there is a pair-wise difference between VNAD and LIS students as well as VNAD and LOS students for TSM 1 with low effect sizes of 0.12 and 0.14, respectively, using Cliff's delta scale of 0 being the lowest effect and 1 being the highest effect (Macbeth et al., 2011). No significant pair-wise differences existed within TSM 2. Lastly, post hoc tests for TSM 3 revealed a pair-wise difference between LIS and VNAD students with a low effect size of 0.10. The post hoc findings indicate there is a significant difference between the lateral students and VNAD students in their academic performance during their three terms of enrollment and that there is no significant difference between the VAD students and lateral students, or VAD students and VNAD students. It is also possible these results are due to the statistical power for VNAD students, which has a larger sample size than the other subgroups. However, in general, the lateral transfer students seem to experience the lowest degree of transfer shock with a decrease of 0.3–0.5 GPA points, while the VNAD students had the highest degree of transfer shock with a decrease of 0.6 GPA points.

An additional Welch's *F*-test was conducted to understand possible significant differences between engineering transfer students and FTIC students at the university. The reduced GPA may be due to the academic rigor of the institution. Using data from 2019 to 2013 for FTIC and transfer students admitted to engineering, a Welch's *F*-test found there were statistically significant differences in the academic performance in the first term of enrollment, with FTIC students performing better than transfer students; $F(4,270) = 16.21$, $p < .001$. A post hoc analysis shows a pair-wise difference between FTIC and VNAD students with a low effect size of 0.24.

5.3 | Chi-square

To determine if differences in 4-year graduation rates exist across the engineering transfer student subgroups, a chi-square analysis was used. Table 6 provides the 4-year graduation rates across each subgroup. The average 4-year graduation rate for engineering transfer students was 76%.

The lateral engineering transfer students have a higher 4-year graduation rate than vertical engineering transfer students. Of the vertical engineering transfer students, VAD students graduated at higher rates. The chi-square analysis confirms the factors are dependent and have a significant relationship. A Cramer's V of 0.11 indicates there is a small effect size using the Cramer's V scale for three degrees of freedom, which indicates 0.06 for small effect size, 0.17 for medium effect size, and 0.29 for large effect size (Cohen, 1988). This finding highlights the largest engineering transfer student population, the VNAD students, have the lowest graduation rates.

It is difficult to compare the transfer graduation rates to FTIC student graduation rates. Transfer students enter the receiving institution at different points in the curriculum than FTIC students. The 4-year, 5-year, and 6-year graduation

TABLE 7 Logistic regression results (odds ratio) for graduated engineering in 4 years

Predictor	β (SE)	95% CI for odds ratio Lower	Odds ratio	Upper
Constant	−3.43*** (1.02)			
Transfer GPA	1.79*** (0.31)	3.30	6.04	11.26
TSM 1	0.99*** (0.17)	1.94	2.71	3.82
TSM 2	0.86*** (0.16)	1.74	2.38	3.27
TSM 3	0.63*** (0.15)	1.41	1.88	2.53

Note: $R^2 = .21$ (Hosmer–Lemeshow), .20 (Cox–Snell), .30 (Nagelkerke), model $\chi^2(1) = 163.80$.
Abbreviations: CI, confidence interval; R^2, coefficient of determination; TSM, transfer shock measurement; β (SE), standard error; χ^2, chi-square statistic.
***$p < .001$.

rates for FTIC students who entered the university during the same timeframe (2009–2013) were 44%, 69%, and 72%, respectively. At any metric point, the engineering transfer students are graduating at higher rates than the university's FTIC students. However, it is important to also consider the length of time the transfer students were enrolled at their sending institutions.

5.4 | Logistic regression

Findings from the previous questions indicate lateral transfer students experience less transfer shock and have higher 4-year graduation rates. Conversely, VNAD students experience a greater level of transfer shock and have lower 4-year graduation rates. To determine if transfer shock is a predictor of 4-year graduation rates, we used logistic regression. Several models were developed that included variations of the following variables: transfer GPA; transfer student subgroup; the three transfer shock measurements; student demographics; and transfer credits earned before transferring as well as interaction models for all combinations of variables. An initial model using only student demographics produced an Akaike information criterion (AIC) value of 821 with no statistically significant variables. Adding the number of transfer credits to the model decreased the AIC to 819, and the number of transfer credits was found to be statistically significant ($p < .01$). While the number of transfer credits earned was found statistically significant on some models, as the TSM values were added to the model, the significance of the number of transfer credits decreased. The model providing the lowest AIC of 697, which indicates the best fit, did not include the number of transfer credits as a statistically significant variable (Field et al., 2012). The results showed:

$$\begin{aligned}\text{Predicted logit of graduated in 4years} = & -3.4335 + (1.7981) * \text{Transfer GPA} + (0.9976) * \text{TSM 1} \\ & + (0.8660) * \text{TSM 2} + (0.6223) * \text{TSM 3}.\end{aligned} \tag{1}$$

Variance inflation factors (VIFs) were used to test for multicollinearity, values over 10 are generally considered problematic (Field et al., 2012). The VIF results for each independent variable are less than two, indicating the variables are not correlated. Table 7 provides the logistic regression model output as well as the fit and accuracy, which indicates the model provides a good fit.

Odds ratios greater than 1 indicate that as the predictor increases, the odds of the outcome occurring increases (Field et al., 2012). Each of the four predictor variables has positive odds ratios, meaning an increase in each will increase the odds of the student graduating in 4 years. Specifically, using transfer GPA as an example, for every 1-point increase in transfer GPA, the likelihood of a student graduating in 4 years increases by approximately six times. As a reminder, students with a positive TSM performed better in the post-transfer term than their transfer GPA.

Transfer GPA has a medium effect, and the TSM values are all small effect sizes. The transfer type, student demographic variables, and number of transfer credits were not found to be significant predictors in the best fit model. There were also no significant interactions found among any of the variables. These findings confirm that transfer GPA and transfer shock in each of the first three terms may be predictors of graduating in engineering within 4 years.

TABLE 8 Mean and standard deviation (SD) for each transfer shock measurement (TSM) level

Level	Shock measurement	TSM 1 mean (SD)	TSM 2 mean (SD)	TSM 3 mean (SD)
1	0 or higher	0.28 (0.28)	0.27 (0.26)	0.31 (0.30)
2	– (0.1–0.49)	−0.25 (0.14)	−0.25 (0.14)	−0.24 (0.14)
3	– (0.5–0.74)	−0.61 (0.07)	−0.62 (0.07)	−0.61 (0.07)
4	– (0.75–1.24)	−0.96 (0.14)	−0.96 (0.15)	−0.97 (0.14)
5	−1.25 or below	−1.78 (0.53)	−1.80 (0.51)	−1.79 (0.51)

TABLE 9 Number and percent of students in each transfer shock measurement (TSM) level

Level	Shock measurement	TSM 1	TSM 2	TSM 3
N		789	789	789
1	0 or higher	21%	20%	22%
2	– (0.1–0.49)	34%	29%	30%
3	– (0.5–0.74)	15%	14%	15%
4	– (0.75–1.24)	19%	22%	19%
5	−1.25 or below	11%	15%	14%

It would be useful to also explore how a change in an FTIC student's high school GPA compared with their first terms of enrollment may be predictors of their persistence in engineering. Unfortunately, we did not have that data to compare in this study; however, it should be a future research topic to better understand similarities and differences between FTIC and transfer engineering students.

5.5 | Grouping analysis

Given the large standard deviation in the TSM variables, we grouped the TSM values into five levels to better understand the influence of transfer shock on 4-year graduation rates. The mean and standard deviation of the categories are presented in Table 8, and the number and percentage of students in each level are presented in Table 9.

The five levels were determined using the average transfer GPA and sampling different ranges of TSM values to determine ranges with a similar distribution, considered meaningful to academic standing, and that provided an ease of use for practitioners. These categories also significantly reduced the standard deviation. Each category represents the transfer shock value, which is the term GPA minus the transfer GPA at the receiving institution.

Table 10 demonstrates the graduation rates of students based on the maximum transfer shock students experience in their first three post-transfer terms. The lowest level is level 1, which has a zero or positive change in GPA compared with the transfer GPA. The highest amount of transfer shock is level 5, which has a decrease of 1.25 points or more in a post-transfer term GPA compared with the transfer GPA. For example, if a student had a −1.25 or below TSM value during any of three post-transfer terms, level 5 would be their highest level of transfer shock.

A chi-square analysis indicates there is a significant difference, and a Cramer's V of 0.42 indicates a small effect size. These findings support the importance of monitoring student progress past the first post-transfer term and understanding each student's level of GPA change.

5.6 | Limitations

This study has several limitations. First, it is focused on a single university, which limits the generalizability of the results to other institutions. Specifically, the university is a large, public, land-grant university with a top-ranked college of engineering.

TABLE 10 Graduation rates in engineering by highest transfer shock measurement (TSM) level

TSM level	*N*	Graduated in engineering within 4 years
1	51	96%
2	158	94%
3	126	87%
4	238	80%
5	216	48%

Second, 444 students from the dataset were missing complete data and were omitted from the final dataset. The omitted students provide a different mix of engineering transfer student subgroups than the students used in the analysis. A higher percentage of LIS students were in the data analyzed, and vertical transfer students with no associate degree had a lower percentage in the final dataset than the subset that was excluded. The LOS and VAD categories are very similar in their numbers. Most of the missing data were in the earlier years, indicating these data are being requested and documented with more regularity, which can improve future studies.

Third, in this study, there was no differentiation between a student leaving engineering or leaving the institution. Students choose to leave an institution or change their major for different reasons, which are not accounted for in this study. This is a concern highlighted by Forney and Kim (2020), who underscore the importance of considering students who may begin in a STEM field but change to a non-STEM major and find success. Future studies should attempt to account for this differentiation.

Fourth, we were unable to compare the engineering transfer students with engineering FTIC students with similar amounts and types of transfer credits. Future studies should carefully consider this type of comparison to explore possible similarities and differences between how each student population acclimates to the institution.

Fifth, other variables were not available within the dataset that may help understand and differentiate engineering transfer students. These variables include students' major at their sending institution, motivations for transferring, financial need, and specific courses that were completed before transferring as well as many others that may also help understand how to influence engineering transfer students' persistence.

Lastly, while Tinto's SIM was the guiding framework, this study did not address all of the components of his model. The study does not address faculty and staff interactions, which is an important component of academic integration. Social integration and the additional components that influence social integration are also not discussed in this study. Additionally, there is a need to consider further pre-entry attributes such as the student's financial need, and goals and commitments of engineering transfer students such as their original intentions of completing a bachelor's degree as well as family and employment commitments that may have influenced their academic integration into their receiving institution. These components of the model were not available in our dataset but should be considered and sought out in future research studies on this population.

6 | DISCUSSION

Previous research on transfer students has focused mainly on vertical transfers (Tobolowsky & Cox, 2012). A growing number of transfer students are entering as lateral transfers (Shapiro et al., 2018), which creates a need to focus research efforts also on lateral transfer students. Lakin and Cardenas Elliott (2016) found vertical engineering transfer students experience higher levels of transfer shock than horizontal engineering transfer students. However, we are unaware of any research that disaggregates the engineering transfer student population into the four distinct subgroups as has been done in this work (i.e., LIS transfer students, LOS transfer students, vertical transfer students with an associate degree, and vertical transfer students with no associate degree). Further, previous research has found transfer shock to be an impactful event for transfer students (Anderson-Rowland, 2011; Hutton & Panter, 2015; Lakin & Cardenas Elliott, 2016; Mattis & Sislin, 2005). However, this concept is most often identified as occurring in the first post-transfer term.

In this work, we have disaggregated the engineering transfer student population into four subgroups and analyzed their transfer shock in the first, second, and third post-transfer terms, including the impacts on 4-year graduation rates. The results uncover several main findings. First, engineering transfer students are not a homogenous population. There are distinct subgroups that have different characteristics and transition differently to the institution. Second, students experience a prolonged "transfer shock" that is perhaps better defined as "transfer norming." Third, a student's transfer norming experience influences their ability to graduate from engineering within 4 years. Lastly, graduation rates of engineering transfer students are slightly better than the FTIC students. The following discussion will expand on each of these points and provide recommendations for practitioners as well as future directions for researchers.

6.1 | Engineering transfer student subgroups

The engineering transfer students were divided into four subgroups: LIS, LOS, VAD, and VNAD. Differences were found in their TSM in the first three terms as well as among their 4-year graduation rates. A deeper analysis revealed the differences were constrained to the VNAD students compared with the laterals transfer students. There were no statistically significant differences between LIS and LOS students. Additionally, there were no statistically significant differences between the lateral and VAD students or the VAD and VNAD students. The lateral students tended to be the most successful students, and VNAD students tended to be the least successful, with VAD students somewhere in the middle.

This finding supports the current research trend that focuses on increasing the persistence of vertical transfers. However, it provides some new directions for this research area that includes understanding why VAD students are more successful than VNAD students and determining why students are transferring before completing their associate degree. Additionally, continuing the comparison of lateral transfers with the VNAD transfers may also point to reasons why the VNAD students are less successful. This comparison should include pre-transfer coursework completion, the length of time at the community college post-high school as well as academic and social integration differences post-transfer. Developing additional admissions criteria may be necessary if differences in pre-transfer coursework completion are found to be a significant factor. Perhaps it is not the completion of the associate degree but completion of a certain course or set of courses that leads to a better transition experience and improved graduation rates for VAD students. If there is a difference in the amount of time spent at the community college between VAD and VNAD transfer students, academic maturity could be a factor in the imbalance between VAD and VNAD students (Addison et al., 2009). However, it is possible the VNAD students were enrolled at the community college for a similar amount of time as the VAD students but were unable to finish the degree requirements. If the VNAD students were enrolled for the same length of time as VAD students, it is important to determine why the VNAD students were unable to complete the requirements of the associate degree and why they chose to transfer before the degree was completed. These findings can provide important directions for institutions as they consider onboarding and transition programming for the various student subgroups.

Little is known about lateral transfer students. Their increasing numbers and their high level of success are important to better understand. There have been previous discussions of swirling and double-dipping (de los Santos & Wright, 1990; Gose, 1995), and McCormick (2003) discusses supplemental, concurrent, and trial enrollment. However, swirling and double-dipping imply students attend multiple institutions but have a home base. Higher education and engineering education should also consider the students who choose to fully leave their initial 4-year institution in pursuit of a similar degree at a different 4-year institution, as was the case with the lateral transfer students in this study. Future research of lateral transfer students should consider if the lateral transfer students are attending similar sending institutions as their receiving institution, are they transferring to an institution in their residency state but different from the state of their current institution, and did they originally apply to their receiving institution. Answers to these questions can provide sending institutions with information on how to possibly retain students who are likely to consider transferring and provide better information for institutions to make strategic enrollment management plans. As institutions become more selective, they may find students they are denying as an FTIC student are attending other 4-year institutions with the intent of applying as lateral transfer students in a subsequent admissions cycle.

6.2 | Transfer norming

The term transfer shock was coined in 1965 to describe a transfer student's temporary drop in GPA during their first term of enrollment at the receiving institution (Hills, 1965). However, the findings from this study suggest that this drop is not temporary. The first post-transfer term has the least net change in GPA, and the highest net GPA change is in the second post-transfer term. The third post-transfer term shows some improvement compared with the second post-transfer term but is still a larger net GPA change than the first post-transfer term. Based on these findings, it is appropriate to consider this phenomenon as more of a transfer norming experience that takes place for each student rather than a singular transfer shock. Transfer norming refers to a more permanent performance standard for each student, as opposed to a temporary shift that will return to its previous state.

From a researcher's viewpoint, it would be useful to understand to what degree did a student's decreased GPA influence their decision to leave engineering. Understanding how prevalent attrition is due to students earning a lower GPA will allow the engineering education community to determine how impactful this experience is to engineering transfer student persistence.

For practitioners, Tinto's SIM calls for institutions to provide appropriate programming to support retention. Diaz (1992) encouraged institutions to determine how long it takes for students to recover from transfer shock. The transition from transfer shock to transfer norming suggests moving away from recovery tactics and instead develop tactics to assist students with a norming experience. This includes more transparency and support for engineering transfer students to make them aware of this experience and help them be able to manage their new normal.

6.3 | Transfer norming affects graduation

Transfer GPA was cited by multiple researchers as a predictor of student persistence, with a higher transfer GPA leading to a higher persistence rate (Ivins et al., 2017; Lakin & Cardenas Elliott, 2016; Lopez, 2012). Additionally, a higher first post-transfer semester GPA was cited by researchers as a predictor of increased persistence rates (Anderson-Rowland, 2011; Laugerman et al., 2015). The findings in this study also found transfer GPA as well as the level of transfer shock in the first post-transfer term as predictors of students graduating in 4 years. However, the findings also demonstrated that students' transfer shock in the second and third post-transfer terms were also predictors of graduating in 4 years.

Using the GPA change scale, students who experience less than 0.5 points of a decline in GPA across the first three post-transfer terms have the highest graduation rates. Students who experience a decrease of 1.25 GPA points or more during any of their first three post-transfer terms have the lowest graduation rates. While transfer norming may be inevitable, limiting the level of GPA change should be a focus for institutions and researchers. Providing a more successful initial transition could then provide the foundation for better second and third post-transfer terms. A better understanding of high-impact practices that can improve transfer norming is needed.

Tinto's SIM recommends institutions provide support for all students and not focus support on specific populations. To follow that call, institutions should develop longitudinal support programs for engineering transfer students, in addition to being transparent regarding the level of transfer norming engineering transfer students should expect at that institution. The programming should consider needs for each subgroup but should not be designed exclusively for any one type of engineering transfer student. Additional research is needed to determine the specific elements that should be incorporated into longitudinal programming. Initial components should be designed based on current onboarding programming for engineering transfer students. However, the support structure should not end after one semester, it should continue until at least the students' third term of enrollment.

6.4 | Graduation rates

The National Center for Education Statistics (NCES) published a report in 2018 that included graduation rates for transfer students overall for the 2009–2014 cohorts. This report indicated 61% of transfer students entering a 4-year public institution will graduate from that institution within 8 years, and 55.7% of FTIC students entering a 4-year public institution will graduate in 8 years (Ginder et al., 2018). Our findings of engineering transfer students graduating at higher rates than FTIC students align with the NCES report. Additionally, both the transfer and FTIC graduation rates in this study are well above the national averages reported by NCES (Ginder et al., 2018).

The findings in this study also align with previous researchers who found vertical engineering transfer students with an associate degree have higher persistence rates than transfer students without an associate degree (Darrow & Laanan, 2012; Hutton & Panter, 2015). As institutions look to increase their transfer student population as a means to increase enrollment, it is important to consider the eventual success of transfer students and their ability to graduate. Enrollment will only solve a short-term problem; the students who have the best odds of finishing their degree should be admitted. Four-year institutions and 2-year institutions should partner to encourage and incentivize completion of the associate degree, which will lead to increased graduation rates for 2-year institutions and provide students with a better chance at success post-transfer.

The findings in this study also indicate lateral engineering transfer students have higher graduation rates than vertical transfer students. This finding does not align with a recent study on all transfer students through the Jack Kent Cooke Foundation, which found vertical transfer students graduated at higher rates than lateral transfer students (Glynn, 2019). The comparison of lateral and vertical transfer students is in its infancy: more comparative studies should be completed across many types of institutions to achieve more disaggregated data for this comparison. It is possible the difference is due to the focus on engineering students in this study or because the institution in this study has high graduation rates. Additionally, Glynn's study focused on selective institutions, which may also lead to differing results.

Research indicates FTIC engineering students who are Black or African American, Hispanics/Latinx, American Indian or Alaska Native, or first generation have a lower likelihood of graduation (Murphy et al., 2010). However, in this study, no individual student demographic was found to be an indicator of graduating from engineering in 4 years for engineering transfer students. This finding needs further exploration across institutions. One possible conclusion is there are fewer diversity graduation gaps in engineering transfer students and would be an important consideration for engineering education and higher education as they look to increase diversity not only in enrollment but in graduates. More refined data for transfer students who include institution type and engineering specific information are needed for better benchmarking of the data.

There are a growing number of reasons why students would want to transfer from one 4-year institution to another, and most likely few of them have to do with academic success. When students complete a lateral transfer, they are decreasing the FTIC graduation rates at their institution but then moving on to another 4-year institution and graduating. This could likely be a reason the transfer students have higher graduation rates than FTIC students. Further research is needed for lateral transfers to provide national-level tracking of eventual completion of a degree. While the FTIC graduation rates have not significantly improved over the last many decades, the number of lateral transfer students is increasing, and they are being successful at their transfer institution. We are losing part of the picture by focusing on persistence institutionally and not viewing students' pathways to a degree more holistically. Determining what percentage of students start a bachelor's degree and finish the bachelor's degree, regardless of if it was at the same institution, will provide a new outlook on student success.

7 | IMPLICATIONS FOR PRACTICE

As a greater number of students are pursuing transfer pathways (Glynn, 2019), engineering transfer students provide an important method of meeting the nation's goal of graduating more engineering students. This study finds that there are key differences between lateral and vertical transfer students, specifically related to vertical transfer students without an associate degree. These findings and recommendations can be useful to the engineering education community as they seek to graduate more engineers as well as enrollment management offices that seek to improve persistence rates at their institutions (Hossler & Bontrager, 2015). For practitioners, this study suggests that more strategic programming and decision-making should be considered by institutions to provide a more focused method for increasing the persistence of their engineering transfer students. For the engineering education and enrollment management communities, this study provides a more granular understanding of engineering transfer students and suggests the key differences among this population that should be considered in future research and recommendations for a more holistic tracking of student's journey to their bachelor's degree. Strengthening the transfer process and acclimation, specifically for associate degree holders and lateral transfers, should be considered as a high-impact practice to increasing bachelor's degree graduates.

8 | CONCLUSION

The purpose of this study was to ascertain key differences when engineering transfer students are disaggregated into distinct subgroups, capturing the type of institution students transfer from (i.e., lateral vs. vertical and in-state vs. out-of-state) and if the students obtained an associate degree when transferring from a 2-year institution. We also focused on reviewing transfer shock and 4-year graduation rates for each of the identified engineering transfer student subgroups.

The results of this study emphasize the importance of institutions understanding that engineering transfer students are not a homogeneous population and that students experience transfer norming rather than transfer shock. Transfer norming not only expands the idea of transfer shock beyond an occurrence solely in the first post-transfer term but rather considers it as a new standard for academic performance for students at the receiving institution. We also demonstrated the engineering transfer student subgroups experience different levels of transfer norming, which is a predictor of their 4-year graduation rates.

The findings from this research are based on a single-institution dataset, and overall are very positive and indicative of a successful engineering transfer student population. Despite the success of engineering transfer students at this institution, several key questions were raised that need further exploration before any generalizability from this study can be applied.

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