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Immersive Summer Transition Program: Exploring the academic performance of first time in college engineering students

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Immersive Summer Transition Program: Exploring the Academic Performance of First-Time-In-College Engineering Students

Abstract- This research paper offers insights into the development and outcomes of an immersive summer transition program for first-time-in-college engineering students. The program's goal was to enhance the academic performance of first-year students and increase their retention in engineering. Specifically, a ten-day, one-credit-hour course was designed to improve first-year students' math readiness, promote on-campus student support services, and encourage collaborative study with peer and peer mentors. Although the program was marketed to students starting in college algebra or precalculus, the program was open to all incoming first-year engineering students. Quantitative data were collected from the first cohort of 40 students who participated in the program at a public, four-year institution in North Carolina before the fall 2023 semester. The program's impact on the students' performance in their first math and introduction to engineering courses, first-term GPA, and retention to the second year was compared to non-participants. Notable findings included an observed increase in academic performance and retention for students who participated in the program compared to those who did not, and grades in the introduction to engineering course were a positive predictor of retention for all first-year engineering students. This study generated practical and actionable findings that will help four-year engineering institutions develop or modify intensive transition programs to improve the academic performance and retention of first-year engineering students.

Keywords: first-time college students, engineering, summer bridge program, and academic success

Introduction and Background

Research indicates that retention rates for STEM students are influenced by several factors, including negative experiences in first-year classes, financial challenges, a sense of not belonging, limited faculty-student and peer interactions, and the demanding nature of the curriculum [1, 2, 3]. The majority of students who leave STEM do so within their first two years. Muller [4] reports that 60% of students exit STEM programs during their first year. Although multiple factors contribute to student attrition in STEM majors, adequate mathematics preparation is critical for student success. Most engineering curricula require students to complete calculus, which often serves as a gatekeeper for advanced engineering courses. In addition, strong foundational skills in mathematics enhance problem-solving abilities, analytical thinking, and understanding of complex engineering concepts, which in turn affect performance in subsequent engineering courses. Therefore, math preparation significantly predicts academic achievement and retention in engineering programs. Numerous studies have highlighted the influence of mathematical skills on engineering success. A 28-year study conducted by Budny et al. [5] found a clear correlation between engineering success and a strong understanding of mathematical principles. Their research also revealed that students earning an A in precalculus had the same retention probability as those who started in Calculus I and earned at least a B, suggesting that mastering foundation material provides the necessary groundwork to obtain an engineering degree. Similar results were reported by Gardner et al. [6], who found that the grades of first-year engineering students in their initial mathematics courses were significantly correlated with their retention in engineering programs.

Bridge programs are a common intervention designed to enhance retention. These intensive programs occur during the summer before the first year of college. According to McSpedon et al. [7], bridge programs consist of components such as academic preparation, institutional acculturation, and cohort development. While bridge programs differ in format, they typically offer strategies to facilitate students' transition from high school to college, which include intensive topic instruction, introduction to campus resources, tutoring, mentoring, and workshops focused on academic skill development [8, 9].

Many summer bridge programs focus on improving students' mathematics skills [10], [11]. Because achievement in first-year mathematics courses is crucial for success in engineering, many summer bridge programs focus on improving students' mathematics skills [10]. Math preparation, indicated by math placement at the institution in this study, has been declining since the COVID-19 pandemic. Consequently, a review of math topics was selected as the focus of instruction for the immersive transition program.

Peer-led support programs supplement classroom instruction by helping students retain course material [8]. Peer mentoring and tutoring often offer more immediate availability and better accessibility, especially during summer terms. They also help students form social connections and receive guidance from peers who have had similar academic experiences. Peer leaders help incoming students build support networks and model the development of problem-solving and critical thinking skills. STEM bridge programs typically offer tutoring sessions, mentoring, and classroom instruction. Therefore, peer leaders were incorporated into the intensive transition program.

Description of the Program

The intensive transition program was a ten-day, one-hour credit course offered at the institution before the start of the fall semester. The program consisted of ten cohorts across the campus. It included academics (e.g., engineering, computer science, mathematics, chemistry, and business) and affinity groups (e.g., Latinex, athletics, transfer students, and students diagnosed with ADHD). The program coordinators were tasked with preparing the content for a one-hour course for their cohorts.

The engineering course was designed to provide incoming first-year engineering students with the essential mathematical practices required to build a strong foundation for their upcoming engineering courses. The course aimed to enhance students' mathematical skills while offering support during the transition from high school to university. By emphasizing the practical applications of mathematics in engineering, we hoped that students would be motivated to see its potential for making a tangible difference in society. The course was developed with the following premises: all students are mathematically brilliant, collaboration expands learning by allowing unique perspectives and strategies to be discovered, and math can be used to read and write the world. The course topics included units and prefixes, exponents, fractions, decimals, ratios, percentages, algebra, solving simultaneous equations, perimeters, areas, and volumes, dimensional analysis, mass, weight, and density.

The target population for the intensive transition program included incoming first-time-in-college (FTIC) students majoring in engineering, engineering technology, and construction management who would be living on campus. The marketing materials recommended the program to students placed in college algebra or precalculus. However, regardless of math placement, the program was open to all FTIC engineering students. The one-hour credit class was free for students, and housing costs were prorated for the ten days.

The program staff included a secondary mathematics specialist who was the primary instructor for the course, one first-year engineering faculty member who developed the course and social activities, and five peer mentors. The peer mentors were sophomore, junior, and senior engineering majors at the institution. The students were divided into five groups, and a peer mentor was assigned to each group. The peer mentor sat with the groups in class, offered study sessions after class, and led engagement activities such as campus tours, attending a minor league baseball game, movie night, a silent disco, an off-campus tour of a large multinational corporation's headquarters, and a team-building challenge.

All intensive transition program cohorts received structured advising, support services, and college engagement activities to promote a successful transition. Students were required to attend five one-hour workshops. At the end of the program, students should be able to effectively identify and use library support services, demonstrate financial literacy in areas such as financial aid, scholarships, and credit/debt, and understand the value of peer relationships in supporting their transition to the institution.

Methods

In this study, we examined the influence of a ten-day intensive transition program on the academic success and retention of 40 FTIC students at a public four-year institution in North Carolina in the fall of 2023. The dataset was compiled from the school's Institutional Research Reporting database, and the first author compiled the qualitative data through a survey sent to the program participants. At the time of the study, the institution's College of Engineering offered five baccalaureate degree programs in engineering and five in engineering technology. A total of 617 FTIC students started their pursuit of engineering in fall 2023. Two questions guided this study:

1. Are there differences in the academic performance of FTIC engineering students who participated in an intensive transition program before the start of their first semester?

2. How do student and academic factors predict the retention of FTIC students in their second year in engineering programs?

For the first research question, we utilized the Mann-Whitney U Test to compare the grades in the students' fall term math class and introduction to engineering classes between students who participated in the intensive transition program and those who did not. Due to data having unequal group sizes and the ordinal nature of the grade variables, a non-parametric statistical test was appropriate to explore the differences related to the program's impact on the student's performance in their first math and introduction to engineering courses. To determine if there was a statistically significant difference between the groups' grade point averages (GPAs), we utilized a one-way analysis of variance (ANOVA) test.

We analyzed the second research question using logistic regression to examine how student backgrounds, participation in the intensive transition program, and first-semester academic performance predict the retention of FTIC engineering students. Students were considered retained if they were still engineering majors at the end of the fall 2024 semester. The semester GPA was selected as a measure of academic success in the first semester at the receiving institution, as it is the most commonly used measure in educational research and assessment [12]. While there has been debate in recent years about the usefulness of using GPA to indicate academic success, the GPA requirements for engineering students to remain eligible to continue in engineering after the first term remain strict.

Variables

All variables were selected based on the literature and available data. Table 1 provides the names, descriptions, and coding for each variable in the study.

Student Background Variables

Student background variables included three student sociodemographic characteristics (sex, race, and applied for financial aid) and participation in the intensive transition program. The definitions of the sex and race variables are essential to highlight. Sex was defined as male or female, as no other sexes or genders were reported in the dataset. While race in the dataset included the nine IPEDS race categories, only five dummy-coded identities were explored in this study: Black or African American, Hispanic of any race, White, Asian, and other races. The category of 'other races' was created by combining four low-incidence (n < 30) categories: non-resident alien, race and ethnicity unknown, American Indian or Alaska Native, and Native Hawaiian or Other Pacific Islander, all of which represent marginalized groups in higher education. Financial aid indicates whether a student submitted a FAFSA Application for Federal Financial Aid. Participation in the intensive transition program was considered a background variable because the program was voluntary, available, and free to all FTIC engineering students, and it was completed before the start of the fall semester.

Table 1. List and Description of Variables in the Study

Variable Name	Variable Type	Description
Student Background		
Gender	Categorical	Dummy coded: 0= male, 1= female
Race	Categorical	Dummy coded: 1=Black, 2=Hispanic, 3=Other, 4=Asian, 0=White[a]
Financial Aid	Categorical	Dummy coded: 0= did not apply for federal financial aid, 1= applied for federal financial aid
Program Participation	Categorical	Dummy coded: 0= did not participate; 1=completed Intensive Transition program
Academic Performance		
High School GPA	Continuous	Weighted, measured on a 0.00 to 5.42 scale
Math Placement Level	Ordinal	4= start in calculus I or higher, 3= start in precalculus, 2= start in college algebra, and 1= starts in college algebra
First Math Course	Ordinal	Dummy coded: 5= A, 4= B, 3= C, 2= D, 1= F, 0= withdraw or withdraw due to extenuating circumstances
First Engineering Course	Ordinal	Dummy coded: 5= A, 4= B, 3= C, 2= D, 1= F, 0= withdraw or withdraw due to extenuating circumstances
First-Term GPA	Continuous	Measured on a 0.00 to 4.00 scale
Retention	Categorical	Dummy coded: 0=left institution; 1= retained at the institution but changed to non-engineering major; 2= retained in the college of engineering

Note: [a] denotes a reference variable

Academic Performance Variables

Academic performance variables included weighted high school GPA, math placement level, grade in their first mathematics and introduction to engineering or engineering technology course during the fall 2023 semester, GPA during the fall 2023 semester, and retention in engineering at the end of the fall 2024 semester. The institution uses a traditional grading system that does not include pluses or minuses. Therefore, the grades were dummy-coded, where 5 indicated that the student earned an A in the course and 1 an F. Students who withdrew from the courses or withdrew due to extenuating circumstances and had a grade of W or WE, respectively, were coded as 0.

Engineering technology programs require that students start in college algebra or pre-calculus, while engineering majors start in Calculus I. However, a student's math placement score determined which starting mathematics course they would take. The math placement score is associated with math ACT or SAT scores or a math placement test used by the institution. Therefore, engineering majors can start in a lower math course, such as college algebra or precalculus, or engineering technology students can begin in Calculus I or higher. Correspondingly, all engineering technology students in this study could enroll in the Introduction to Engineering Technology course in their first semester. In contrast, engineering majors could enroll in the Introduction to Engineering course if they were enrolled in Calculus I or higher.

Results

Descriptive Findings

A total of 617 FTIC students began pursuing a baccalaureate degree in engineering during the fall 2023 semester. The fall 2023 cohort predominantly identified as White (59.5%) and male (82.2%). Black or African American students accounted for 10.2% of the sample, with Hispanic (15.4%), Asian (8.9%), and other race (6.0%) students making up significantly smaller proportions. Most students applied for financial aid by completing a FAFSA application (87.8%). Of these students, forty participated in the intensive transition program before the start of the fall semester. The program participants predominantly identified as White (70.0%) and male (77.5%). Black or African American students accounted for 12.5%, Hispanic (10.0%), Asian (2.5%), and other races (5.0%) of the program participants. Eighty-five percent of the participants applied for financial aid.

On average, the fall 2023 cohort of FTIC engineering students had a weighted high school GPA of 3.95 (SD=0.62), and program participants had the same average high school GPA of 3.95 (SD=0.35). Table 2 provides a summary of math placement levels for both groups. A higher percentage of non-participants were placed at math level 4 (or started in Calculus I or higher), while a higher percentage of program participants were placed at math level 3 (or pre-calculus).

Table 2. Summary of Math Level Placement

Math Level	Non-Participant (n= 577)	Program Participants (n=40)
1	11.8%	13.2%
2	11.8%	10.5%
3	21.4%	28.9%
4	54.9%	47.4%

A summary of first-term course grades for Introduction to Engineering or Engineering Technology and Mathematics courses is presented in Table 3. Engineering technology students were eligible to take Introduction to Engineering Technology regardless of math level placement. However, engineering students could only take Introduction to Engineering if placed in math level 4 or had credit for Calculus I. The median grade in the Introduction to Engineering course was an A for both groups and a B for the first mathematics course for both groups. A higher percentage of program participants earned an A in their engineering and math courses and had lower rates of Fs, Ws, or WEs. The average first-term GPA of program participants was 3.23 (*SD*=0.64) and 3.08 (*SD*=0.80) for non-program participants.

Table 3. Summary of Selected First-Term Grades

Grade	Non-Participant (n= 577)		Program Participants (n=40)	
	Engineering (n=376)	Math (n=556)	Engineering (n=26)	Math (n=40)
A	52.9%	32.9%	57.7%	40.0%
B	25.0%	30.4%	30.8%	27.5%
C	12.0%	20.5%	11.5%	20.0%
D	2.4%	6.3%	-	7.5%
F	2.4%	5.8%	-	2.5%
W or WE	5.3%	4.1%	-	2.5%

A summary of the retention data is provided in Table 4. A higher percentage of program participants were retained in engineering programs at the end of the fall 2024 semester than non-participants. Interestingly, students who completed the intensive transition program were retained at the institution at a much higher rate than non-participants.

Table 4. Summary of Retention

	Non-Participant (n= 577)	Program Participants (n=40)
Retained in Engineering or Engineering Technology	75.6%	80.0%
Retained in a Non-engineering degree	9.5%	17.5%
Left institution	14.9%	2.5%

Inferential Findings

First, we performed a one-way between-groups analysis of variance (ANOVA) to explore students' academic performance before they started at the institution, as measured by their weighted high school GPA. The fall 2023 cohort of FTIC engineering students was divided into two groups according to whether they participated in the intensive transition program before the start of the fall semester. There was no statistically significant difference in the weighted high school GPAs between the groups, $F(1, 615) = .000$, $p = .996$. This test indicated that the prior academic performance of the two groups was similar.

A Mann-Whitney U Test was run to determine if there were differences in first-term course grades between students who participated in the intensive transition program and those who did not. Distributions of first-term engineering course grades of program participants were not similar to those of non-participants, as assessed by visual inspection. Engineering course grades for participants (mean rank = 220.00) and non-participants (mean rank = 200.22) were not statistically different, $U = 4407$, $z = -.921$, $p = .357$, using an exacting sample distribution for U (Dineen & Blakesley, 1973). Similarly, the distributions of first-term math course grades of program participants were not similar to those of non-participants, as assessed by visual inspection. Mathematics course grades for program participants (mean rank = 321.74) and non-participants (mean rank = 296.83) were not statistically different, $U = 10190$, $z = -918$, $p = .359$, using an exacting sample distribution for U.

Prediction of FTIC Engineering Student Retention

We performed a binomial logistic regression to determine the effects of student background and academic performance variables on the likelihood that FTIC students will be retained in engineering. Linearity of the continuous variables (e.g., high school GPA and first-term GPA) with respect to the logit of the dependent variable (retention) was assessed using the Box-Tidwell procedure [13]. A Bonferroni correction was applied using all 14 terms in the model, resulting in a statistical significance being accepted when $p < .00357$[14]. Based on this assessment, all continuous independent variables were found to be linearly related to the logit of the dependent variable. After inspection, three standardized residuals with values of 3.791, 3.975, and 4.473 were kept in the analysis.

Table 5. Prediction of Retainment for FTIC Engineering Students (n=617)

Variable	B (SE)	Odds Ratio	95% CI for Odds Ratio	
			Lower	Upper
Student Background Predictors				
Female	-.38(.42)	.67	.30	1.55
African American	-.57(.73)	.56	.14	2.35
Hispanic	-.02(.45)	.98	.41	2.35
Other	.26(.60)	1.30	.40	4.21
Asian	.65(.45)	1.92	.79	4.63
Financial Aid	-.74(.46)	.48	.19	1.17
Transition Program	-.96(.77)	.39	.09	1.74
Academic Performance Predictors				
High School GPA	-.57(.34)	.57	.29	1.10
Math Placement Level	-.05(.17)	.95	.68	1.32
First Math Course	-.08(.14)	.93	.70	1.23
First Engr Course	.49(.14)	1.64***	1.24	2.16
First-term GPA	-4.56(1.98)	.01*	.00	.50

Note. B=regression coefficient; *SE*= standard error
The reference variable for Race/Ethnicity was White, for Gender was Male, for Financial Aid did not apply, and for Intensive Transition did not participate
**p*<.05, ***p*<.01, ****p*<.001

The model was entered into one block, which included the student background predictors (gender, race, application for federal financial aid, and participation in the intensive transition program and academic performance predictors (weighted high school GPA, math placement level, grades in first-term math and engineering courses, and first-term GPA). The logistic regression model was statistically significant, $\chi^2(12) = 67.312$, $p < .001$. The model explained 26.9% (Nagelkerke R^2) of the variance in persistence and correctly classified 81.8% of the cases. The sensitivity was 95.5%, the specificity was 34.6%, the positive predictive value was 83.4%, and the negative predictive value was 69.2%. The estimated coefficients, standard errors, and odds ratios (*OR*) are presented in Table 5.

Of the twelve predictor variables, the relative likelihood of retention in engineering was significantly associated with first engineering course grade and first-term GPA. There was a statistically significant and positive association between the first engineering course grade and the probability of persistence or baccalaureate degree attainment ($OR = 0.63$, $p < .001$, 95% CI [0.37, 0.76]). This result indicates that the odds of FTIC engineering students remaining in engineering programs at the end of the fall 2024 semester were 1.64 times more likely for each letter grade increase in their first engineering course. First-term GPA was a negative and statistically significant predictor ($OR = 4.56$, $p = .021$, 95% CI [0.00, 0.50]). However, the odds ratio was close to zero, indicating negligible differences in the odds.

Discussion and Future Work

A ten-day intensive transition program was designed to improve FTIC engineering students' math readiness, build connections with their peers, and develop strategies for success in their first semester. The results of our study demonstrated the program's positive impact on students. Specifically, there was an observed difference in the academic performance and retention of FTIC engineering students who completed the program. Key takeaways of this study include (a) the high school GPAs between program participants and non-participants were statistically similar, (b) program participants earned higher course grades in their first engineering and math courses, and had higher GPAs during the fall 2023 semester compared to non-participants, (c) a higher percentage of program participants remained in engineering programs (4.4%) or at the institution (8%) at the end of the fall 2024 semester compared to non-participants, and (d) first-term grade in Introduction to Engineering significantly predicted retention of FTIC students in engineering programs.

The finding that a relatively short-duration transition program can positively impact incoming FTIC engineering students is consistent with extant research on summer bridge programs [15], [16]. Before the start of the program, the first-year engineering faculty had noted a decline in foundational math skills in the introduction to engineering courses over the previous five years, which was compounded following the COVID-19 pandemic. To address this issue, the ten-day intensive transition program was created to support incoming engineering students. The program was designed to provide students with an intensive review of foundational mathematical concepts, engage them in multiple team-building activities, inform students about campus support services, and help them make meaningful connections with their peers, peer mentors, and engineering faculty. More analyses will be necessary to explore the success of the engagement and collaborative learning aspects of the program. However, the results of this study are promising for engineering faculty and administrators interested in creating similar programs at their institutions.

An interesting finding from our study was that a student's grade in their Introduction to Engineering or Introduction to Engineering Technology course was a positive predictor for retention in engineering programs; however, their grade in their first-term mathematics course was not found to be a predictor. This finding does not align with the extensive research on the relationship between mathematics grades and retention in engineering [5], [6]. We reviewed the learning outcomes for the introduction to engineering courses to gain insight into our findings. The project-based learning courses include four multidisciplinary projects that allow students to apply foundational math and elementary electrical, mechanical, civil, and systems engineering theory to design, build, test, and analyze a solution that meets specific requirements and performance specifications. While the D, F, and W rates for these courses have been historically low at the institution, the course has served as an impetus for students to confirm their commitment to their respective engineering majors. Our findings appear to support this notion. A future study should explore the experiences of those who leave the major in their first year to understand how introductory engineering courses contribute to their decision.

In future evaluations, we plan to analyze qualitative data to understand how well the engagement activities and collaborative learning environment impact the program participants. Unfortunately, for the fall 2023 cohort, only 6 out of 40 students completed the survey sent out near the end of the first term on campus. Our second cohort, consisting of 65 FTIC students, completed their first semester at the institution in the fall of 2024. This cohort was sent evaluation surveys on the last day of the program, and we encouraged all participants to complete the survey. Fortunately, all students completed the engagement survey. In the future, we plan to incorporate qualitative metrics to help us understand how the program aligns with the college's strategic plan for increasing retention and persistence among FTIC engineering, engineering technology, and construction management students.

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