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Mind Over Math: How Confidence and Beliefs Predict Academic Performance and Retention in First-Year Engineering

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Introduction and Background

The transition to higher education is a period of significant uncertainty that can leave students disoriented, requiring them to exercise greater personal control over their environment to achieve academic success [1], [2], [3], [4], and [5]. Central to this transition is the development of self-efficacy, the belief in one's ability to organize and execute the actions required to achieve specific outcomes [1] and [2]. This belief is particularly critical in engineering, where a nationwide decline in math readiness has become a primary driver for students leaving the discipline [5], [6], [7], [8], [9], and [10]. Because engineering curricula rely on rigorous prerequisite chains that start with Calculus, students who lack the ability to master and apply mathematical concepts will likely experience graduation delays of 1 to 2 years [8] and [9]. Although faculty view this "mathematical maturity" as the primary desired outcome of students' math coursework, its deficiency among first-year students is a major driver of attrition because it leaves students feeling disoriented during the high-uncertainty transition into engineering [5] and [8].

This study evaluates the Intensive Engineering Transition (IET) program, a ten-day immersive summer bridge course designed to bridge the "math gap". Grounded in Bandura's four sources of self-efficacy[1], this research employs a mixed-methods approach to examine how first-year engineering students' mathematical beliefs and confidence influence their subsequent academic performance and retention. Ultimately, this work aims to provide scalable frameworks for improving student persistence in demanding engineering environments.

Theoretical Framework

According to Bandura, "Perceived self-efficacy refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments [1, p. 3]." These beliefs influence the paths and actions students follow, the effort they put into completing a task, their resilience when faced with adversity, whether their internal thoughts help or hinder them, the level of stress or depression they experience when facing difficult demands, and their accomplishments. The stronger their sense of efficacy, the lower their stress, transforming a student's internal thought patterns from self-hindering to self-aiding and laying the groundwork for long-term academic accomplishment [1] and [11].

Bandura [1] proposes that self-efficacy beliefs are formed from four main sources: mastery experience, vicarious experiences, verbal persuasions, and emotional and physiological states.

Mastery Experiences: Research indicates that mastery experiences is the most influential source of self-efficacy since it provides students with credible evidence of their ability to succeed [4], [12], [13], and [14]. When individuals successfully achieve a complex task, they gain direct evidence of their capabilities, which significantly strengthens their confidence. Bandura [1] indicates that once a strong sense of efficacy is established through repeated success, occasional setbacks are less likely to decrease self-efficacy. Lent [2] conducted a study exploring the sources of information students use to appraise their mathematics self-efficacy. Students indicated their personal past successes as the most common and influential factor in their efficacy beliefs.

Vicarious Experiences: Self-efficacy is also shaped by observing others, particularly peers or role models. Watching a similar individual successfully complete a difficult task can raise their belief in their own potential to succeed [15]. On the other hand, Bandura [3] suggested that seeing a peer fail despite high effort can lead individuals to doubt their own abilities. In a classroom setting, witnessing a classmate solve a complex problem can strengthen a student's belief in their own mathematical potential. In a study by Usher [4], students were found to evaluate their own mathematical capabilities by observing and interpreting their peers' performance.

Verbal Persuasion: Verbal encouragement and social feedback serve as the third pillar of self-efficacy. Positive reinforcement from credible sources, such as parents and instructors, can inspire students to persevere through difficult tasks. Research indicates that supportive home environments and constructive instructional feedback are vital in shaping a student's mathematical self-belief, whereas negative interactions can quickly undermine it [4], [16], [17], and [18].

Physiological and Emotional States: Finally, an individual's physical and emotional well-being significantly informs their perceived efficacy. High levels of stress, anxiety, or fear are often interpreted as signs of a lack of skill. According to Bandura [3], reducing these emotional triggers can improve performance. Therefore, creating a supportive, non-threatening classroom environment helps students manage "math anxiety," thereby allowing them to focus on learning rather than their own physiological distress.

Description of the Program

The Intensive Engineering Transition (IET) Program is a ten-day, one-credit bridge course designed to ease the transition from high school to university for incoming first-time-in-college (FTIC) students majoring in engineering, engineering technology, or construction management. By positioning the course immediately prior to the fall semester, the program provides students with a critical opportunity to improve their foundational mathematical skills in an active-learning, collaborative environment. The curriculum is intentionally scaffolded to move beyond rote calculation, instead emphasizing the practical application of mathematics in engineering to solve tangible societal problems. This pedagogical approach is designed to foster early professional identity while addressing the "math gap" often encountered during the high school-to-university transition. The course content covers a rigorous range of topics, including units and prefixes, exponents, fractions, ratios, and percentages, as well as more advanced applications such as simultaneous equations, dimensional analysis, and geometric modeling of mass, weight, and density.

While the program is open to all incoming FTIC engineering students residing on campus, recruitment efforts specifically target those placed in College Algebra or Precalculus to bolster retention in these foundational courses. To maximize accessibility and minimize financial barriers, the one-hour credit is provided tuition-free by funding from Truist Bank. On-campus housing and dining costs are prorated for the duration of the ten-day period. The program's instructional model utilizes a high-touch, collaborative staffing structure led by a secondary mathematics specialist and a first-year engineering faculty member. This leadership is complemented by nine upper-division engineering peer mentors who are assigned to specific student cohorts. These mentors serve as guides, sitting with their groups during instruction to assist with problem-solving, facilitating evening study sessions, and leading a variety of social and professional engagement activities. These activities range from off-campus tours of multinational corporate headquarters to team-building challenges and social outings, such as movie and trivia nights, all intended to build a robust peer support network- see *Appendix* for IET program schedule.

Complementing the academic and social components is a series of structured advising and support services designed to promote long-term success. Participants are required to attend five one-hour professional development workshops that focus on holistic student growth. By the conclusion of the program, students are expected to demonstrate a high level of institutional literacy, specifically in the use of library research services and in the management of personal finances, including scholarships and financial aid. Ultimately, the program aims to instill a deep understanding of the value of peer relationships, ensuring that students enter the fall semester not only mathematically prepared but also socially integrated and equipped with the navigational capital necessary to succeed in a demanding engineering environment.

To provide a comprehensive, data-driven foundation for the program, the leadership team implemented a dual-layered diagnostic strategy before the first day of instruction. This initial assessment phase was designed to capture both quantitative proficiency and qualitative background for each participant. The first component consisted of a formal pre-assessment quiz administered via the institution's Learning Management System. This twelve-problem, multiple-choice instrument targeted specific mathematical competencies essential for engineering success, including unit conversions, dimensional analysis of density and weight, geometric area calculations, and the algebraic manipulation of simultaneous equations, fractions, and exponents. By identifying specific areas of deficiency early, instructors were able to calibrate the curriculum's pace and focus to meet the cohort's immediate needs.

The second component of the pre-course assessment was a reflective narrative assignment in the form of a personal letter addressed to the instructor. In this document, students were encouraged to articulate their academic history as mathematics students and reflect on their previous experiences in collaborative or team-based environments. This qualitative insight enabled the faculty to understand the diverse psychological and social backgrounds of the incoming cohort, leading to more personalized mentorship and more effective group dynamics. Together, these assignments provided a holistic profile of each student, enabling the intensive ten-day program to be adjusted to address both technical gaps and interpersonal strengths.

Methods

In this study, we examined the influence of students' math beliefs before the start of college on the academic success and retention of 64 FTIC students at a public four-year institution in North Carolina in the fall of 2024. The dataset was compiled from the school's Institutional Research Reporting database and student assignments completed during the transition program. The research was deemed Non-Human Subjects because de-identified data were used for quantitative and qualitative analyses. At the time of the study, the institution's College of Engineering offered ten baccalaureate degree programs in engineering and engineering technology. A total of 694 FTIC students started their pursuit of engineering in fall 2024. Three questions guided this study:

1. To what extent is initial mathematics placement level associated with first-semester academic performance among FTIC engineering students?
2. How do students describe their mathematics experiences prior to college? And how do these previous mathematics experiences compare to their academic performance in their first mathematics course?
3. How do students' mathematical background factors predict the retention of first-year engineering students in their second year in engineering programs?

To examine whether academic performance differed between students who participated in the intensive transition program and those who did not, we used a one-way analysis of variance (ANOVA) to compare weighted high school GPAs. Additionally, we used the Mann-Whitney U Test to compare fall-term math grades between students who participated in the intensive transition program and those who did not. Due to unequal group sizes and the ordinal nature of the grade variables, a nonparametric test was appropriate to examine differences in the program's impact on students' performance in their first math course.

To address our first research question, a Pearson product-moment correlation was used to assess the strength and direction of the relationship between a FTIC engineering student's math-level placement and their academic performance. For the purposes of this analysis, academic performance was operationalized as the participant's cumulative grade point average (GPA) at the conclusion of their first semester. Preliminary analyses were conducted to ensure the data met the necessary statistical assumptions, including linearity, normality, and homoscedasticity. By correlating math placement, a proxy for incoming academic preparedness, with first-term GPA, this study sought to quantify the predictive validity of standardized placement metrics on early-stage persistence and success within the engineering curriculum.

To interpret students' prior experiences with mathematics, we utilized their "Math Autobiographies," preassessment data, and first-semester math grades. The analysis included multiple readings of the student documents to identify recurring phrases and experiences. Using Bandura's [1] four sources of self-efficacy as a theoretical framework, we coded the data and organized it into distinct categories. By comparing and contrasting these categories, we identified the patterns necessary to address our research question.

We analyzed the third research question using logistic regression to identify predictors of retention among FTIC engineering students in their second semester. The dependent variable, student retention, was defined as a binary outcome indicating whether a student remained enrolled in an engineering, engineering technology, or construction management major at the conclusion of the Spring 2025 term. The model included independent variables such as student demographic backgrounds, participation in the intensive transition program, and pre-college mathematical experiences.

Additionally, first-semester GPA was included as a primary predictor of academic success. While scholarly discourse has recently questioned the holistic utility of GPA as a sole indicator of student potential, it remains a critical metric in this study because it serves as a gatekeeping mechanism at the study's institution. Engineering programs typically enforce rigorous minimum GPA thresholds that students must maintain to remain in good standing and progress through the curriculum. Therefore, despite broader debates in educational research, first-semester GPA remains a highly relevant and objective measure of a student's ability to meet the immediate institutional requirements of the engineering college [19]. Using logistic regression, this analysis sought to quantify the odds ratios for retention based on these multifaceted academic and programmatic variables.

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.

Program Participants Math Background Variables

Student background variables included the program participants' math background before the start of the fall semester and consisted of variables "math beliefs", "math teamwork", "program pre-assessment", "math level placement", and "self-efficacy source." Math beliefs, math teamwork, and self-efficacy were coded from an assignment titled "Math Autobiography," which was due before the start of the intensive transition program. Students were asked to write a letter to their instructor introducing themselves and describing their experiences with teamwork, memories from previous math classes (e.g., from kindergarten through the present), positive experiences with math, and experiences working in a team in a math class.

The letters were coded using descriptive and concept coding strategies. Descriptive coding summarizes data into a single word or short phrase and is typically the focus of qualitative data analysis [20]. Key words and phrases were identified from the transcript, and the description was noted. Similar descriptions were uncovered, and the responses regarding math beliefs were coded as "highly positive," "positive," "neutral," or "negative." "Highly positive" included words or phrases in which students expressed a love for math or indicated that math was their favorite subject. "Positive" phrases included "one of my favorite subjects," "liked math," "comes easily to me," while "neutral" words included "never a favorite subject… but some good experiences," "not the strongest subject," or did not express a positive or negative math experience. "Negative" phrases included "most intimidated by math." Following the coding, it was observed that only one student reported negative experiences with math, whereas many students described math as their favorite subject. Therefore, the researchers combined the "highly positive" and "positive" responses and the "neutral" and "negative" responses for the statistical model.

Experiences with working in math teams were coded to have "math team experience" and "no math team experience." Of the 64 responses, no student reported a negative experience with the math team. The codebook was exported to Excel, and quotations were added to support the codes.

Table 1. List and Description of Variables in the Study

Variable Name	Variable Type	Description
Program Participant Math Background Factors		
Math Beliefs	Categorical	0= negative or neutral math experiences, 1= positive math experiences
Math Teamwork	Categorical	0= no experience working with a team in a math course, 1= has worked with a team in a math course
Program Pre-Assessment	Continuous	Percentage correct out of 100%
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
Self-Efficacy Source	Categorical	1= Mastery Experiences, 2= Vicarious Experiences,3= Verbal Persuasion, 4= Physiological/Emotional States
Academic Performance Factors		
High School GPA	Continuous	Weighted, measured on a 0.00 to 5.42 scale
First Math Course Grade	Ordinal	6= A, 5=B, 4=C, 3=D, 2=F, 1= withdraw, 0= no math course in first semester at institution
First-Term GPA	Continuous	Measured on a 0.00 to 4.00 scale
Retention	Dichotomous	Dummy coded: 0=left institution or left engineering; 1= retained in an engineering major

Note: [a] denotes a reference variable

We adopted Saldaña's [20] deductive structural coding approach, utilizing Bandura's [1] four sources of self-efficacy(SE) as a predetermined conceptual framework to index and categorize our data. Participant responses were indexed into four specific categories: 1 = Mastery Experiences, 2 = Vicarious Experiences, 3 = Verbal Persuasion, and 4 = Physiological and Emotional States. This method ensured that all data relevant to self-efficacy were captured within these theoretical buckets, providing a systematic foundation for identifying the patterns required to address our research question.

While a few students may have described other sources of belief the most predominant source was used for coding. Examples of sentences coded for Mastery Experience (1) are "... always good at math… ," "... math has always been my strong subject … ," and "... math comes easily to me … ."For Vicarious Experiences (2) an example is "... Math hasn't always been a natural thing for me so to combat this I would hold study sessions with one of my friends … ." An example of Verbal Persuasion is "Although she was a tough teacher, the overall experience was great because I had learned so much and she even encouraged me to find other ways to solve the equation…” and “... [my mom] motivates me and teaches me new things every day… .” Finally, an example of Physiological and Emotional States is “ … I feel nervous about taking this class. Math hasn’t always been my strongest subject … .” The statements closely parallels the survey phrases utilized in a study conducted by Usher and Pajares to validate the sources of self-efficacy [14].

Although the standard curricula for engineering technology and engineering majors typically begin with Precalculus and Calculus I, respectively, a student’s actual entry point is dictated by an individual mathematics placement score. This placement is determined by a triangulated assessment of ACT or SAT mathematics sub-scores, the institution’s ALEKS math placement examination, or college credit. Consequently, an engineering major may be required to begin coursework with foundational courses such as College Algebra, while an engineering technology student with high quantitative proficiency may begin with Calculus I or beyond.

The institution utilizes a tiered placement system to ensure students are matched with a curriculum appropriate to their current competency levels. A Level 4 placement authorizes enrollment in a three-credit-hour Calculus I course. Students who achieve a Level 3 placement are assigned to a three-credit-hour Precalculus course. Finally, students placed at Level 1 or 2 are required to complete a four-credit-hour College Algebra course, which provides the intensive foundation necessary for subsequent engineering coursework.

The program pre-assessment variable is the student’s score on the twelve-problem online quiz. The score represented the percentage of correct multiple-choice responses targeting specific mathematical competencies essential to engineering success.

Academic Performance Variables

Academic performance variables included weighted high school GPA, grade in their first mathematics course during the fall 2024 semester, GPA for the fall 2024 semester, and retention in engineering at the end of the spring 2025 semester. The institution uses a traditional grading system that does not include pluses or minuses. Therefore, the grades were dummy-coded: 6 indicated an A, 2 an F. Students who withdrew from the courses or withdrew due to extenuating circumstances and received a grade of W or WE, respectively, were coded as 1. While uncommon, a few FTIC students did not take a mathematics course during their first semester. However, all program participants enrolled in a mathematics course during the fall 2024 semester.

Results

Descriptive Findings

A total of 694 FTIC students began pursuing a baccalaureate degree in engineering during the fall 2024 semester. The fall 2024 cohort was predominantly White (54.6%) and male (79.5%). Black or African American students accounted for 9.8% of the sample, with Hispanic (17.9%), Asian (11%), and other race (6.8%) students making up significantly smaller proportions. Most students applied for financial aid by completing a FAFSA application (88.6%). Of these students, 64 participated in the intensive transition program before the start of the fall semester. The program participants predominantly identified as White (57.8%) and male (75%). Black or African American students accounted for 14.1%, Hispanic students (17.2%), Asian students (3.1%), and other races (7.8%) among the program participants. Approximately 94% of program participants applied for financial aid.

On average, the fall 2024 cohort of FTIC engineering students had a weighted high school GPA of 4.01 (*SD*=0.39), and program participants had the same average high school GPA of 4.02 (*SD*=0.32). Table 2 summarizes math placement levels for both groups. A higher percentage of participants were placed at math level 3 (or started in Precalculus), whereas a higher percentage of non-program participants had a missing math placement level. Students who did not submit scores for the ACT or SAT exams or who did not take the ALEKS Math Placement exam through the university did not have a math placement score. These students started in College Algebra unless they have AP or transfer credit for College Algebra, Precalculus, or Calculus.

Program participants completed a pre-assessment quiz, with an average score of 69.3% (SD = 19.01).

Table 2. Summary of Math Level Placement

Math Level	Non-Participant (n= 630)	Program Participants (n=64)
1	8.3%	9.4%
2	7.1%	6.3%
3	14.8%	21.9%
4	44.3%	62.5%
Missing	25.6%	None

A summary of the coded and categorized program participant responses regarding math beliefs and experience working in math teams before starting at the university is presented in Table 3. The majority of students expressed neutral or positive math beliefs, whereas only 1 student expressed a dislike of math. Regarding team experiences, the majority of students reported favorable or neutral perceptions of working in teams in their previous math courses. However, nearly half of the students indicated that they have worked on teams in other subjects but not in their math courses.

A summary of first-term course grades for students' first-term mathematics courses is presented in Table 4. A higher percentage of program participants earned a B in their math courses and had lower withdrawal rates, including those due to extenuating circumstances. The average first-term GPA of program participants was 3.11 (*SD*=0.09), and that of non-program participants was 3.08 (SD=0.03).

Table 3. Count of Previous Math Experiences for IET Program Participants

Code	Math Beliefs	Math Team Experiences
0	33	40
1	31	24
Total	64	64

A summary of the retention data is provided in Table 5. A higher percentage of program participants were retained in engineering programs at the end of the fall 2024 semester than non-participants.

Table 4. Summary of Selected First-Term Mathematics Course Grades

Grade	Non-Participant (n= 595)	IET Program Participants (n=63)
A	33.7%	31.3%
B	33.0%	35.9%
C	14.1%	15.6%
D	5.6%	6.3%
F	5.1%	7.8%
W or WE	3.0%	1.6%

Table 5. Summary of Retention

	Non-Participant (n= 630)	IET Program Participants (n=64)
Retained in the College of Engineering	76.0%	87.5%
Changed to a non-engineering major or left the institution	24.0%	12.5%

Inferential Findings

First, we conducted a one-way between-groups analysis of variance (ANOVA) to examine students' academic performance before entering the institution, as measured by their weighted high school GPA. The fall 2024 cohort of FTIC engineering students was divided into two groups based on whether they participated in the intensive transition program prior to 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 two groups' prior academic performance was similar.

Similarly, we performed a Mann-Whitney U Test to determine if there were differences in the first-term mathematics course grades between students who participated in the intensive transition program and those who did not [21]. Visual inspection of the histograms indicated that the distributions of first-term engineering course grades for program participants were similar to those for non-participants. Both distributions were slightly negatively skewed- see Table 4 for the frequencies of first-term mathematics grades. A test of homogeneity of variance was conducted by computing Levene's statistic, and it was found to be not significant [22]. Mathematics course grades for program participants (mean rank = 317.09) and non-participants (mean rank = 330.81) were not statistically different, $U = 17960$, $z = -.572$, $p = .568$, using an exact test based on the U distribution. The results of these analyses indicate that math performance before the start of the semester and after the first term was similar among FTIC engineering students, regardless of participation in the intensive transition program.

To answer our first research question, a Pearson product-moment correlation was conducted to assess the relationship between a FTIC engineering student's math-level placement and their academic performance in their first semester, as measured by their first-term GPA. Preliminary analyses showed the relationship to be linear, with both variables normally distributed (Shapiro-Wilk's test, $p > .05$) and no outliers. There was a statistically significant, small positive correlation between students' math placement level and first-term academic performance, $r(688) = .11$, $p < .021$, with a student's math level accounting for only 1% of the variance in first-term GPA.

Qualitative findings

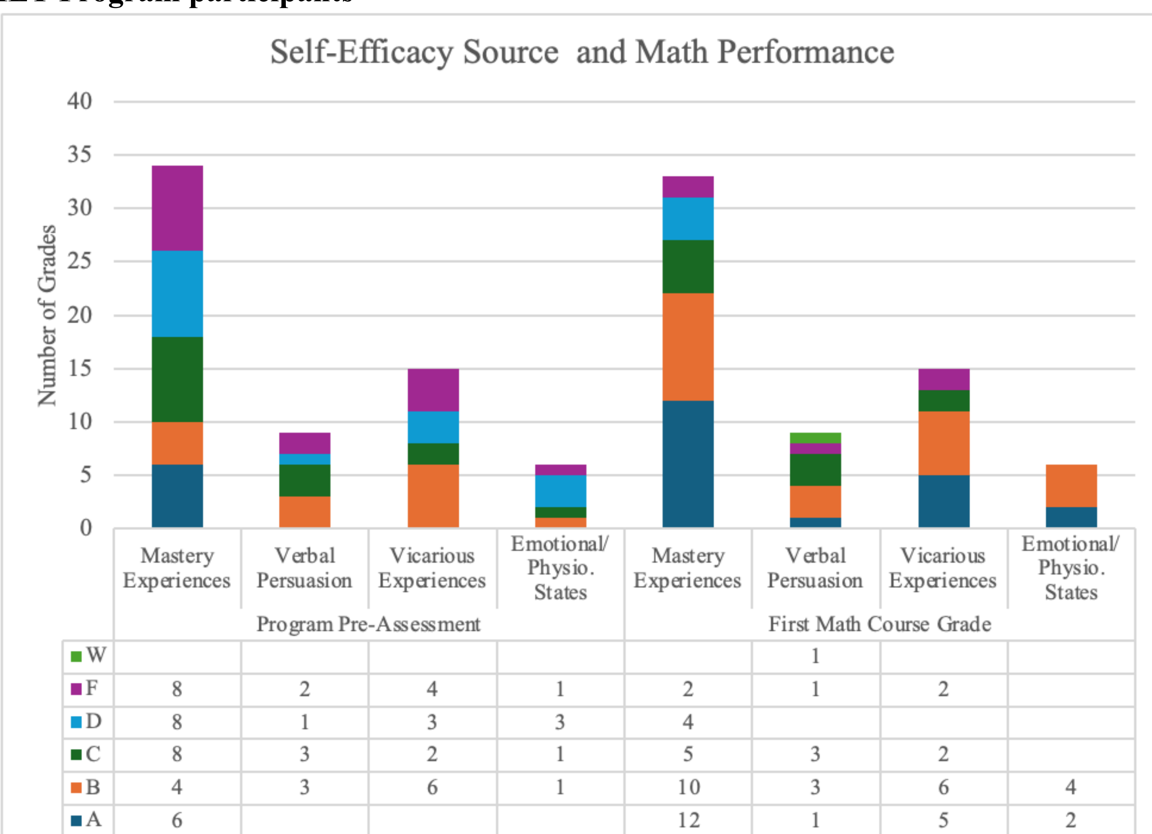
To understand the impact of a student's math beliefs based on their previous math experiences, we analyzed their "Math Autobiographies" alongside their performance on pre-assessments and in their initial math courses. Table 6 summarizes the coding for the "Math Autobiography." As shown, more than half of the students are confident in their ability to perform math based on their mastery. Approximately a quarter of the students indicated that they feel more confident in their math ability when they work with their friends; 14% of the students indicated that their confidence in math came from encouragement from teachers or parents, and close to 10% expressed that they are nervous about their ability to do well in the math courses.

We also explored whether the source of self-efficacy affected students' performance on the preassessment and in their first math course. The preassessment numeric grades were converted to letter grades for comparison with the first math course final grades (0-59 = F, 60-69 = D, 70-79 = C, 80-89 = B, 90-100 = A). Figure 1 shows the preassessment and first math course grade distribution by the self-efficacy source. All self-efficacy source groups show improvement from preassessment to the first course final grade in mathematics. The number of failing grades for the Mastery and Vicarious Experiences groups decreased. This may be due to students gaining confidence in their ability to succeed in mathematics courses through instruction and group work. The largest gain was for the Emotional/Physiological States. There were no grades of C, D, or F, possibly indicating that, as a result of participating in the IET program, students became less nervous about their ability to succeed in math courses.

Table 6. Summary of Self-Efficacy Sources

SE_Sources	IET Participants (n= 64)
Mastery Experiences	53.1%
Vicarious Experiences	23.4%
Verbal Persuasion	14.1%
Physiological & Emotional States	9.4%

Figure 1. Self-Efficacy Sources, Preassessment, and First Math Course Final Grade for IET Program participants



	Mastery Experiences (Program Pre-Assessment)	Verbal Persuasion (Program Pre-Assessment)	Vicarious Experiences (Program Pre-Assessment)	Emotional/ Physio. States (Program Pre-Assessment)	Mastery Experiences (First Math Course Grade)	Verbal Persuasion (First Math Course Grade)	Vicarious Experiences (First Math Course Grade)	Emotional/ Physio. States (First Math Course Grade)
W						1		
F	8	2	4	1	2	1	2	
D	8	1	3	3	4			
C	8	3	2	1	5	3	2	
B	4	3	6	1	10	3	6	4
A	6				12	1	5	2

Prediction of FTIC Engineering Student Retention

We performed a binomial logistic regression to assess the effects of math background and experience, and academic performance variables, on the likelihood that participants in the summer intensive program will be retained in engineering. Linearity of the continuous variables (e.g., program pre-assessment and first-term GPA) with respect to the logit of the dependent variable (retention) was assessed using the Box-Tidwell procedure [23]. A Bonferroni correction was applied using all 7 terms in the model, resulting in statistical significance being accepted when $p < .007$ [24]. Based on this assessment, all continuous independent variables were found to be linearly related to the logit of the dependent variable.

The model was entered into two blocks: the first included student math background predictors (math beliefs, math teamwork, pre-assessment, and math placement level), and the second included academic performance predictors (high school GPA, first-term math course grades, and GPA). The logistic regression model was not statistically significant, $\chi^2(7) = 9.97$, $p = .190$. The model explained 27.5% (Nagelkerke R^2) of the variance in persistence and correctly classified 88.9% of the cases. The sensitivity was 98.2%, the specificity was 25.0%, the positive predictive value was 84.3%, and the negative predictive value was 66.7%. The estimated coefficients, standard errors, and odds ratios (*OR*) are presented in Table 7.

Table 7. Prediction of Retainment for FTIC Engineering Students (n=64)

Variable	B (SE)	Odds Ratio	95% CI for Odds Ratio	
Student Math Background Predictors				
Math Beliefs	-.67(.89)	.51	.09	2.87
Math Teamwork	1.08(.91)	2.95	.51	17.41
Pre-Assessment	**.06(.03)**	**1.06***	**1.00**	**1.12**
Math Placement Level	.21(.53)	1.24	.44	3.52
Academic Performance Predictors				
High School GPA	-2.31(1.62)	.10	.01	2.38
First Math Course	-.11(.57)	.90	.29	2.76
First-term GPA	1.57(1.01)	4.78	.66	34.80

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

Of the seven predictor variables, the relative likelihood of retention in engineering was significantly associated with students' pre-assessment quiz grade. There was a statistically significant, positive association between the pre-assessment score and the probability of persistence or baccalaureate degree attainment (*OR* = 1.07, $p < .05$, 95% CI [1.00, 1.12]). 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 higher 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 [1.00, 1.12]). Higher pre-assessment quiz scores in the IET program were associated with a higher likelihood of retention.

Discussion and Future Work

Engineering education faces a significant challenge due to a nationwide decline in math readiness, as evidenced by declining ACT and SAT scores, which indicate a lack of "mathematical maturity" among incoming students [6] and [7]. Since undergraduate engineering programs rely on rigorous prerequisite chains starting with Calculus, students who must first take remedial courses like College Algebra or Precalculus often face delays of one to two years in graduation [5] and [6]. This lack of mathematical readiness has been identified as a primary driver of students' departure from engineering [10]. Ultimately, the starting position in the mathematics sequence is highly correlated with the probability of successfully graduating from an engineering program.

To address this issue, the researchers in this paper designed a ten-day intensive transition program to improve FTIC engineering students' math readiness and to provide opportunities to build connections with peers and develop strategies for success in their first semester. Two assignments were created to help the course's instructors establish a data-driven foundation for the program. The leadership team implemented a dual-layered diagnostic strategy before instruction began, combining a quantitative pre-assessment quiz with a qualitative reflective narrative. The formal quiz targeted essential engineering competencies (e.g., dimensional analysis, geometric calculations, and algebraic manipulation) to allow instructors to calibrate the curriculum's pace to specific technical deficiencies. Simultaneously, the reflective personal letters provided insight into students' previous mathematical and collaborative experiences, enabling faculty to foster personalized mentorship and more effective group dynamics. By integrating these two instruments, the program developed a holistic profile of the cohort, ensuring the curriculum addressed both immediate mathematical gaps and the diverse interpersonal backgrounds of the participants.

These course assignments, along with institutional data, were utilized to understand how first-year students' mathematical background, including academic performance (i.e., math level placement, high school GPA), and beliefs and experiences relate to their academic performance and retention in engineering. Key takeaways of this study include (a) the academic background between program participants and non-participants was statistically similar, (b) a higher percentage of program participants remained in engineering programs at the end of the spring 2025 semester compared to non-participants [87.5% versus 76%], (c) students' math placement level was found to be statistically related to their first semester academic performance, (d) program participants expressed varying math beliefs with half of the participants stating that math was either their favorite or one of their favorite classes, while the other half expressed having both good and bad previous math experiences, (e) program participant's score on the preassessment quiz significantly predicted retention of FTIC students in engineering programs.

While students' math placement level correlated with their first-semester GPA, it was not a statistically significant predictor of retention by the end of their second semester. This link between initial math readiness and early academic performance aligns with existing engineering education research [25]; however, the finding that placement does not predict retention contradicts the broader literature [10]. This discrepancy highlights a critical area for future study, particularly regarding the trajectories of students who depart the program. Further investigation is needed to determine if these students migrated to other STEM disciplines within the university or transferred to different institutions to continue their engineering education.

To better understand these differences, we conducted a qualitative analysis of students' letters using Bandura's [1] theory of perceived self-efficacy as a theoretical framework, specifically exploring how the four sources of self-efficacy influenced performance on their preassessment quiz and in their subsequent first mathematics course. We found that all self-efficacy groups demonstrated marked improvement in their grade distribution from the program assessment to their course grades in mathematics. Notably, the Mastery and Vicarious Experience groups saw a significant reduction in failing grades, likely reflecting increased confidence fostered by the program's targeted instruction and collaborative environment. The most evident gains, however, were observed in the Emotional/Physiological states group, in which no student earned a C, D, or F in their mathematics course, suggesting that the program effectively mitigated math-related anxiety and enabled students to translate improved emotional regulation into academic success. Future work is needed to explore these findings. One option is to develop a qualitative assessment of peer-to-peer interactions during the IET program, using focus groups to identify which specific collaborative activities (e.g., problem-based learning vs. peer-led team learning) most effectively reduce math anxiety and increase self-efficacy.

In conclusion, while further analysis is required to fully isolate the impact of the IET program's engagement and collaborative learning components, these preliminary results offer a promising model for engineering faculty and administrators. The findings suggest that such initiatives can effectively bridge early competency gaps and bolster student confidence, providing a scalable framework for institutions seeking to enhance math readiness and retention in engineering disciplines.

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Appendix

	FRIDAY August 9	SATURDAY August 10	SUNDAY August 11	MONDAY August 12	TUESDAY August 13	WEDNESDAY August 14	THURSDAY August 15	FRIDAY August 16	Saturday August 17
9:00 AM	**Introductions and Engineering FIT Overview via Zoom Meeting**		Scavenger Hunt- cont'd- on your own	**Lecture #2 and Problem Solving:** Exponents Colvard 1017	**Lecture #4 and Problem Solving:** Algebra Colvard 1017	**Lecture #5 and Problem Solving:** Solving Simultaneous Equations OR **Ventures: Team Challenge Course** Colvard 1017	**Lecture #7 and Problem Solving:** Unit Conversions and Dimensional Analysis Colvard 1017	Final Exam Colvard 1017	
9:15 AM									
9:30 AM									
9:45 AM									
10:00 AM		Opening Ceremony (Lucas/McKnight Hall)							
10:15 AM								Engineering FIT Reflection and Awards	
10:30 AM				Quiz 1 and Review	Quiz 2 and Review	Quiz 3 and Review	Quiz 4 and Review		
10:45 AM	Asychronous **Lecture 1: Units and prefixes** and Assessment Quiz (on Canvas)								
11:00 AM				Transition	Transition	Transition	Transition	Transition	
11:15 AM				Academic Skill Development/Lunch McKnight Hall	Lunch	Atkins Library/Lunch Atkins Library	Finances/Lunch Woodward 106	Center for Integrated Care/Lunch Woodward 106	
11:30 AM									
11:45 AM									
12:00 PM		Move-in Time			Meet at Lightrail Station- Travel to Uptown Charlotte				
12:15 PM									
12:30 PM			Lunch with your Peer Mentors						
12:45 PM									
1:00 PM									FIT Recognition Ceremony Dubois Center
1:15 PM				Transition	Honeywell Tour	Transition	Transition	Transition	
1:30 PM				**Lecture #3 and Problem Solving:** Fractions, Decimals, Ratios, and Percentages Colvard 1017		**Lecture #6 and Problem Solving:** Perimeters, Areas, and Volumes Colvard 1017	**Lecture #8 and Problem Solving:** Force, weight, mass, and gravity Colvard 1017	Student Panel Discussion with TAs and MAPS Coaches Colvard 1017	
1:45 PM									
2:00 PM			Campus Tours						
2:15 PM									
2:30 PM									
2:45 PM									
3:00 PM						Transition			
3:15 PM				Break		**Lecture #5 and Problem Solving:** Solving Simultaneous Equations OR **Ventures: Team Challenge Course** Colvard 1017	Study Session 2: with Peer Mentors Colvard 1017	Optional: UREC Outdoor Pool Party	
3:30 PM									
3:45 PM				Study Session 1: with Peer Mentors Colvard 1017	Meet at Lightrail Station- Travel to UNC Charlotte				
4:00 PM									
4:15 PM			Complete Lecture 1 and Assignments						
4:30 PM					Transition				
4:45 PM									
5:00 PM		Scavenger Hunt- on your own							
5:15 PM						Giant Game Night! (Belk Plaza)	Transition		
5:30 PM									
5:45 PM									
6:00 PM									
6:15 PM									
6:30 PM									
6:45 PM									
7:00 PM									
7:15 PM									
7:30 PM									
7:45 PM									
8:00 PM			Movie Night REC Field 14A (next to Undergraduate Admissions Building)						
8:15 PM									
8:30 PM									
8:45 PM									
9:00 PM									