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Academic Preparedness and Performance: A Study of First-Year Students in Mathematics, Physics, and Computing Courses

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Introduction

First-year students enter college with diverse backgrounds and varying levels of preparedness for their higher education journey. These prior experiences and skills, encompassing both academic and social competencies, significantly influence their overall college experience.

Pre-academic skills play a crucial role in facilitating the transition to college, especially in STEM fields where students are required to pass introductory course credits. Students with strong academic foundations typically adjust more easily to college coursework compared to those with weaker skills.[1] Academic resources such as tutoring, advising, faculty interaction, and library services can mitigate the challenges associated with this transition. Despite the availability of these resources, it is often incumbent upon students to proactively seek them out to enhance their educational experience[2]. Unfortunately, students who are less prepared for college-level courses frequently lack the knowledge or initiative to access these resources, leading to difficulties in adjustment and lower academic performance.[3]

Academic preparation in high school is a critical factor in determining college success, particularly in STEM fields such as calculus, physics, programming, and chemistry. Research shows that students who engage in rigorous high school coursework and develop strong study habits are better equipped to handle the demands of college-level courses[4]. Thus, students who feel well-prepared in high school are more likely to perform well in college. For instance, students who take advanced placement or AP classes or participate in summer bridge programs tend to have higher levels of academic achievement and are less likely to require remedial courses upon entering college[5]. Early preparation helps students build confidence and reduces the likelihood of feeling overwhelmed by the transition to college.

While the significance of college preparedness in fostering academic success is well documented, there remains a substantial gap in understanding how such preparedness uniquely impacts performance in STEM disciplines among first-year students from a predominantly White institution. Moreover, the complex dynamics between college preparedness, study habits, a sense of belonging, and their collective influence on academic outcomes have not been thoroughly examined.

This study aims to bridge these gaps by investigating the interplay between college preparedness, study habits, a sense of belonging and academic performance in mathematics, physics, and computing courses. Furthermore, the study seeks to uncover disparities in academic outcomes across different academic majors, gender, and racial demographics. By clarifying these relationships, the research seeks to provide actionable insights that can inform the development of targeted interventions to, ultimately enhancing student success.

In early Spring 2024, I surveyed first-year students after they completed their first semester courses in mathematics, physics, and programming. The survey questionnaire provides information about students’ preparedness for classes, the amount of time spent studying and participating in extracurricular activities, and their sense of belonging in the classroom. The methodology employs an ordinary least square model to analyze the impact of these attributes on the grades students achieve in mathematics, physics, and computer science courses.

Results suggest that students who are better prepared for calculus, physics, and programming tend to achieve higher grades in these subjects. This trend is particularly notable among Computer Science (CS) majors and female students. Additionally, a strong sense of belonging significantly enhances student grades. For instance, students who feel comfortable seeking help from professors and have classmates with shared interests perform better in calculus. However, while study hours are crucial for success, excessive study can be detrimental to students' academic outcomes. I found that balancing study hours with non-academic activities and fostering a supportive environment can significantly enhance academic performance.

One of the primary limitations of this study is the small sample size. While the dataset provides valuable insights, a limited number of observations can affect the robustness and generalizability of the results.

In the subsequent sections, I will present a detailed overview of the collected data. Following this, a regression analysis will be conducted to examine the relationships between the key variables. Finally, the results of the analysis and a conclusion will be discussed.

Data

Survey Questionnaire

I used the National Survey of Student Engagement (NSSE) and the Student-Faculty Interaction Survey. The NSSE is designed to understand how students balance their academic responsibilities with other activities, providing insights into their overall high school experience and preparedness for college.[6] Student-Faculty Interaction Survey aims to understand the quality and impact of the relationship between students and faculty.[7]

The assessment items for these surveys include both quantitative and qualitative measures that describe students' levels of preparation for classes, the time spent studying and participating in extracurricular activities, their interactions with faculty and peers, and their comfort in the classroom. Most of the survey questions utilize a five-point or seven-point Likert scale. Additionally, I asked students to self-report their grades for math, physics, and computer science classes in their first two quarters (or first semester).

The survey questionnaire and research protocols have been approved by the Institutional Review Board.

I administered the survey questionnaire in the Spring semester of 2024 to all first-year students enrolled in the 2023-2024 academic year, totaling approximately 1,300 students. A total of 197 students completed the survey, resulting in a response rate of about 15%. After data cleaning to ensure survey completeness, I obtained a final sample of 124 responses.

Descriptive Statistics

Demographics

The characteristics of the respondents are presented in Appendix 1. The data is representative across gender and ethnicity. In the sample, 56% of respondents are male, 10% are non-binary, and 34% are female, which is comparable to the 30% of the first-year female student population. Additionally, the sample includes 65% white students. The remaining racial demographics consist of 4% Black, 4% Hispanic, and 8% Asian students, which are nearly comparable to the overall first-year student population (note that the first-year Hispanic student population is slightly higher at 8%). Furthermore, the survey respondents include 14% first-generation students and 5% economically disadvantaged students.

Level of Preparation for Introductory STEM Courses

I asked students to rate their level of preparation for introductory classes, including calculus, physics, and programming. This question was measured on a 7-point Likert scale, coded as follows: 1 = Far below average to 7 = Far above average.

The summary of the self-reported preparation levels is presented in Table 1. The analysis reveals a diverse range of preparedness among first-year students. On average, students feel more prepared for calculus and Physics as compared to programming. In calculus, students score a mean and standard deviation of 4.74 and 1.73, respectively. This significant variability indicates that while a considerable portion of students feel adequately prepared, a notable number either feel underprepared or exceptionally well-prepared. Specifically, 44% of students consider their preparation level to be average or below, while 46% rate their preparation as slightly above average. These data are also disaggregated across gender, race, and major.

Table 1: Self-reported Level of Preparation for Introductory Courses

Variables	**Observation**	**Mean**	**Std. Dev.**	**Min**	**Max**
Calculus	122	4.74	1.73	1	7
Physics	95	4.78	1.54	1	7
Programming	97	3.95	1.96	1	7

Level of Preparation for Introductory STEM Courses by Gender, Race, and Major

To understand how different demographic groups, perceive their readiness for various academic courses, I disaggregate the level of preparation by Gender and Race, and Major. Results indicate a significant variation in preparation levels between male and female. On average, male students rated their level of preparation higher than female students across all courses. For instance, in calculus, male students scored an average of 5.01 points, compared to 4.42 points for female students.

Racial differences in the level of preparation for introductory courses reveals notable disparities. Minority student group perform better than the white student group in Calculus and Physics. However, within the minority group, Asians consistently score a higher level of preparation.

I also compared CS students to non-CS students. As expected, CS students demonstrated a slightly above-average level of preparation in programming courses, with a mean score of 4.89

compared to 3.42 for students from other majors. But there was no significant difference in the levels of preparation for calculus and physics between CS and non-CS students. On average, CS students are as prepared as their peers in these subjects. The summary of student preparation levels across gender, race, and major is presented in Appendix 2.

Study Habits

To understand students' study habits, I inquired about the amount of time they spend each week preparing for class. This preparation includes a variety of academic activities such as studying, reading, writing, completing homework, and conducting lab work. The objective was to assess the time commitment students allocate to their academic responsibilities outside of scheduled class hours. Responses were measured on a scale from 0 to 7, where 0 represents no time spent studying and 7 represents more than 30 hours of study time. Additionally, I asked students to report the time they spend on co-curricular activities, paid employment, community service or volunteer work, relaxation and socializing, and commuting to campus to understand how these non-academic activities might influence their academic performance.

Results are presented in See Table 2 and reveal several key insights. First, on average, students allocate the majority of their time to studying (11-16 hours), relaxing (6-10 hours), and engaging in co-curricular activities (1-5 hours). To better understand study habits in college, I disaggregate the results by gender, race and major. Results are displayed in Appendix 3.

Findings suggest that both male and female students dedicate approximately 11-15 hours or more per week to class preparation, with males studying slightly more than females. However, there is significant variability in study time, with some students spending as little as 1-5 hours and others exceeding 30 hours per week. Results also suggest that while both males and females participate in co-curricular activities and paid work, females devote more hours to these activities compared to males, confirming previous findings that indicate females spend less time studying. These differences highlight the diverse ways in which students balance their academic and non-academic responsibilities. (See Panel A of Appendix 3)

Racial differences are presented in Panel B and indicate that Minority students spend more time studying, averaging 16-20 hours or more per week, compared to their White peers who average 11-15 hours. Minority students also spend more hours in co-curriculum activities and paid work. Conversely, they spend fewer hours in leisure time.

Finally, a comparison between CS and non-CS majors are presented in Panel C of the same table and shows a slight difference in study time, with CS students averaging 11-15 hours per week, slightly less than their peers in other majors. This small difference suggests that while study habits vary across disciplines, the overall time commitment to academic preparation remains substantial.

Table 2: Hours Spent per Week on Academic and non-academic Activities

Variable	Obs.	Mean	Std. Dev.	Min	Max
Preparation for Class	124	3.605	1.556	1	7
Co-curricular Activity	124	1.508	1.24	0	7
Work for pay on campus	124	0.202	0.541	0	3
Work for pay of campus	124	0.444	1.345	0	7
Volunteering	124	0.25	0.55	0	3
Relaxing	124	2.54	1.456	0	7
Commuting	124	0.492	0.656	0	3

Sense of Belonging

Creating a comfortable classroom environment and fostering a sense of belonging are fundamental to student engagement and success. Students are more likely to feel comfortable and engaged in the classroom when they perceive support from both their peers and faculty.[8] To assess these dynamics, I asked students to rate their interactions with peers and faculty, as well as their overall comfort in the classroom. These interactions were measured using a 7-point Likert scale, with responses ranging from 1 (strongly disagree) to 7 (strongly agree).

Peer Support

The sense of belonging results, as presented in Table 3, indicate that students somewhat agreed (mean = 5.14, SD = 1.18) that if they miss class, they know a peer from whom they can obtain class notes. Similarly, they felt they could contact a classmate if they had a question (mean = 5.19, SD = 1.18). However, students neither agreed nor disagreed about meeting with a peer outside of class to study for a test (mean = 4.47, SD = 2.16) or developing personal relationships with other classmates (mean = 4.77, SD = 1.71). These findings are not surprising for first-year students in a STEM school, where initial social connections may still be forming. The somewhat positive responses regarding peer support for academic needs, such as obtaining class notes and asking questions, highlight the importance of peer networks in academic success. However, the neutral responses regarding social interactions outside of class and personal relationships suggest that first-year students may still be in the process of building deeper connections.

Faculty Support

The results for faculty support, as detailed in Panel B of Table 3, suggest that students somewhat agreed that they feel comfortable asking their professors for help if they do not understand course-related materials (mean = 5.5, SD = 1.38). Additionally, students felt that faculty members genuinely tried to understand their problems when discussed (mean = 5.03, SD = 1.25). Students also reported feeling comfortable attending office hours before and after class (mean = 5.42, SD = 1.29). However, they somewhat disagreed with feeling comfortable asking faculty for help with personal problems (mean = 3.64, SD = 1.72). Faculty support appears to be a strong positive influence, with students feeling comfortable seeking academic help and attending office hours. This underscores the critical role faculty play in creating a supportive academic environment. However, the lower comfort levels in seeking help for personal problems indicate a potential area for improvement in faculty-student relationships.

Classroom Comfort

The classroom comfort results show that students somewhat agreed (mean = 5.17, SD = 1.48) that they feel comfortable contributing to class discussions. They neither agreed nor disagreed about feeling comfortable asking questions in class (mean = 4.96, SD = 1.54), volunteering ideas in class (mean = 4.76, SD = 1.66), or speaking in class (mean = 4.45, SD = 1.63). These results show that while students feel somewhat comfortable contributing to discussions, there is room for growth in encouraging more active participation, such as asking questions and volunteering ideas. Results are reported in Panel C of Table 3

Overall, these data suggest that while students generally feel a sense of belonging in their academic environment, there are opportunities to enhance both peer and faculty support to foster deeper connections and greater engagement. Focusing on these areas can help create a more inclusive and supportive educational experience, ultimately leading to improved academic and emotional outcomes for students.

Additional Measures of Sense of Belonging

To gain a deeper understanding of students' sense of belonging in the classroom, additional questions were asked, focusing on social match and identification with other students in both the classroom and STEM fields. These questions aimed to capture how well students felt they fit in socially and whether they identified with their peers. The assessment was conducted using the 7-point Likert scale discussed above.

The results, presented in Panel D of Table 3, show that, on average, students neither agreed nor disagreed that they can relate to their classmates (mean = 4.45, SD = 1.63), have a lot in common with their classmates (mean = 4.45, SD = 1.63), or that classmates share their personal interests (mean = 4.45, SD = 1.63). However, students agreed that someone like them can succeed in a STEM career (mean = 4.45, SD = 1.63). These findings suggest that while students may feel neutral about their social connections within the classroom, they do perceive a positive impact on their overall academic engagement and motivation when they feel included and supported within the academic community.[9]

Table 3- Sense of Belonging Measures

Panel A	Peer Support				
Variables	**Observation**	**Mean**	**Std. Dev.**	**Min**	**Max**
Peer Help with note	118	5.14	1.58	1	7
Study with peer outside of class	118	4.47	2.16	1	7
Contact peer outside of class	118	5.19	1.58	1	7
Developed Relationship with peer	118	4.77	1.71	1	7
Panel B	**Faculty Support**				
Variables	**Observation**	**Mean**	**Std. Dev.**	**Min**	**Max**
Faculty can help me if I need help	118	5.5	1.38	2	7
Faculty try to understand my problem	118	5.03	1.25	1	7
Comfort seeking help before and after class	118	5.42	1.29	2	7
Comfort asking faculty help with personal problem	118	3.64	1.72	1	7
Panel C	**Classroom Comfort**				
Variables	**Observation**	**Mean**	**Std. Dev.**	**Min**	**Max**
Comfort contributing to class discussion	110	5.17	1.48	1	7
Comfort asking question in class	110	4.96	1.54	1	7
Comfort volunteering idea in class	110	4.76	1.66	1	7
Comfort Speaking in class	110	4.45	1.63	1	7
Panel D	**Additional Measures of Sense of Belonging**				
Variables	**Observation**	**Mean**	**Std. Dev.**	**Min**	**Max**
Relate to peer in the classroom	108	4.71	1.47	1	7
A lot in common with classmates	110	4.67	1.39	1	7
Classmates share personal interests	109	4.66	1.47	1	7
Someone like me can succeed in STEM	110	6.08	1.01	1	7

Grade in Calculus, Physics, and Programming

At this institution, the grading scale ranges from A to No Record (NR), with A being the highest grade and NR being the lowest. Students were asked to self-report their grades in calculus, physics, chemistry, and programming for the A and B terms of Fall 2023. These grades were coded on a scale from 1 to 4, where 1 represents NR "the lowest grade" and 4 represents A "the highest grade". Table 4 presents the overall average grade for term A and B. Result indicate that, on average, students achieved a grade of B or better across all courses. The data also suggest that students received no NR in Physics and Programming during the second term.

Table 4-Grade in Calculus, Physics, and Programming

	Term A					***Term B***				
Variables	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Calculus	69	3.25	0.85	1	4	62	3.03	1.06	1	4
Physics	38	3.53	0.73	1	4	36	3.69	0.52	2	4
Programming	26	3.38	0.98	1	4	21	3.57	0.81	2	4

Regression Analysis

Empirical Specification

To further understand the experience of first-year students, I use regression analysis models to examine how preparation for first-year courses, study habits and sense of belonging in the classroom affect student grades in calculus, physics, or programming courses. I use a multiple linear regression model to estimate these relationships separately and together. The multiple linear regression is a statistical technique to help understand the impact of various student-level factors on a course performance. I estimate the following three equations:

$$Grades_{ic} = \alpha + \beta_1 X_i + \beta_2 Preparation_{ic} + \varepsilon_i \quad (1)$$

In this equation [1], $Grades_{ic}$ is the response variable. It represents the average grade received by a student i in a course c during the first semester.

$Preparation_{ic}$ is the predictor variable. It represents the level of preparation of a student i in a course c. The course of interest here is either calculus, physics, or programming. The parameter β2 represents the average change in the grade for one unit of change in preparation level while holding other variables in the model constant. Xi is a vector of other covariates that represents student characteristics including their gender, race, major, and first-generation status. Finally, εi is the error term.

$$Grades_{ic} = \alpha + \beta_1 X_i + \beta_2 StudyHabits_i + \varepsilon_i \quad (2)$$

In this second equation [2], $StudyHabits_i$ represents the number of hours a student i spends on academic activities *including* studying, reading, writing, completing homework, and conducting lab work. Xi includes covariates that measure experience with high school and college academic work for grade in addition to the student characteristics described in equation 1.

$$Grades_{ic} = \alpha + \beta_1 X_i + \beta 2 SenseofBelonging_i + \varepsilon_i \quad (3)$$

In this third equation [3], $SenseofBelonging_{ic}$ measures the sense of belonging of student *i* in course *c*. This includes various measures of sense of belonging, such as peer support, faculty support, comfort in the classroom, and sense of belonging in the classroom and STEM field. Key measures incorporated in the analysis include whether classmates share personal interests, comfort in seeking help before and after class, and the belief that someone like them can succeed in STEM. $\boldsymbol{X_i}$ includes covariates that measures attitude toward earning A and B in a course in addition to the student characteristics.

Results

Impact of Pre-College Preparation on Calculus, Physics, and Programming

Table 5 presents the results of pre-college preparation on calculus, Physics, and Programming grades for the model presented in Equation (1).

- Model 1: This restricted model accounts for the level of preparation for courses and student characteristics. Columns 1, 3, and 5 of the table present coefficient results for model 1.
- Model 2: This model further expands Model 1 by including student characteristics and interactions between preparation level and demographic variables. Columns 2, 4, and 6 present coefficient results for Model 2.

Table 5: Effect of Pre-College Preparation on Calculus, Physics and Programming Course Grades

	(1)	(2)	(3)	(4)	(5)	(6)
	Avg Grade Calculus		Avg Grade Physics		Avg Grade Programming	
	Restricted	+ Demographics	Restricted	+ Demographics	Restricted	+ Demographics
Preparation Calculus	0.244***	0.266***				
	(0.0604)	(0.0954)				
Preparation Physics			0.185***	0.138		
			(0.0508)	(0.0857)		
Preparation Programming					0.204**	0.268***
					(0.0774)	(0.0632)
Female		0.0471		-0.301		2.358**
		(0.784)		(0.595)		(0.746)
Minority		-1.473		-0.717		-1.240
		(1.830)		(1.304)		(0.719)
CS major		0.493				1.531***
		(0.320)				(0.425)
Female X Preparation Calculus		0.00693				
		(0.164)				
Female X Preparation Physics				0.0231		
				(0.122)		
Female X Preparation Programming						-0.444**
						(0.191)
Minority X Preparation Calculus		0.262				
		(0.328)				
Minority X Preparation Physics				0.177		

				(0.250)		
Minority X Preparation Programming						0.324*
						(0.175)
Other Demographic Variables		Yes		Yes		Yes
Constant	2.013***	2.588*	2.754***	3.106***	2.558***	-1.545
	(0.284)	(1.401)	(0.256)	(0.621)	(0.405)	(1.026)
R-square	0.229	0.301	0.293	0.461	0.279	0.825
Observations	57	49	34	28	20	18

An interaction effect occurs when the impact of one independent variable on the dependent variable varies depending on the level of another independent variable. A positive and significant interaction term suggests that the effect of one independent variable on the dependent variable increases as the value of the other independent variable increases. Conversely, a negative and significant interaction term indicates that the effect decreases.

The main coefficient estimates as presented in column 1 through column 6 suggest a positive correlation between college preparation and grade in Calculus, Physics and Programming. For example, the results for model 1 in column 1 suggest that the level of preparation for calculus is positively associated with academic performance in calculus. Specifically, an increase in preparation level by one scale point is associated with an increase in the average grade in calculus by 0.24 during the first semester. This implies that if a student increases their level of preparation for calculus by 0.6 standard deviation, their grade will increase by 0.3 standard deviation. This effect is significant at $p < 0.01$.

Introducing student characteristics and interaction terms in Model 2 did not change the sign or significance of the coefficient for calculus preparation. Although the interactions between female/minority status and preparation level indicate that female and minority students might see improved calculus grades with higher levels of mathematics preparation, this effect is not statistically significant. In contrast, Model 6 reveals a positive and significant effect for minority students, suggesting that their programming grades increase as their course preparation improves. Additionally, Model 6 indicates that computer science majors tend to achieve higher programming grades than non-CS majors, and female students generally outperform their male peers. However, it also reveals that for female students, an increase in preparation appears to be associated with a decline in their programming grades.

Effects of Study Hours on Grades

Table 6 presents the results on the impact of study habits on grades in calculus (Column 1), Physics (Column 2), and programming (Column 3). The analysis reveals a negative correlation between study hours and grades. This effect is statistically significant for calculus and programming (p-value < 0.10) but not for physics. This finding is unexpected, as previous research typically indicates a positive relationship between study hours and grades[10]. However, it is also suggested that excessive study hours can be detrimental to students' well-being and, consequently, their academic performance.[11]. Interestingly, our results indicate that co-curricular non-academic activity hours are positively correlated with programming grades in Model 2. This result is statistically significant (p-value < 0.05), suggesting the benefit of balancing non-academic activities with study hours.

Calculus and programming model in Columns 1 and 2 offer additional insights. For example, the interaction between minority and study hours suggest that minority students would see their grade increase in calculus and programming with an increase in study hours in these subjects. Although not reported, there seems to be no relationship between hours spent studying in high school and grade in college and students who exert significant effort to achieve high grades in high school tend to perform better in programming courses[12], with this result also being statistically significant (p-value < 0.05).

Table 6: Effect of Study Habits on Calculus and Programming Grades

	(1)	(2)	(3)
	Avg Grade Calculus	Avg Grade Physics	Avg Grade Programming
Study (academic) hours	-0.192*	-0.139	-0.265*
	(0.0978)	(0.0971)	(0.128)
Co-curricular hours	0.178	0.221**	0.0952
	(0.107)	(0.103)	(0.132)
Hour relaxing	0.119	-0.0427	0.0349
	(0.101)	(0.0925)	(0.112)
female	0.700	-0.333	0.0955
	(0.765)	(0.667)	(1.455)
Minority	-0.938	-0.907	0.575
	(0.986)	(0.695)	(1.568)
CS major	-0.00930		-0.235
	(0.339)		(0.814)
Female X Study Hours	-0.191	0.00151	0.0437
	(0.209)	(0.185)	(0.521)
Minority X Study hours	0.394*	0.357*	-0.0331
	(0.233)	(0.201)	(0.283)
Other Demographic Variables	Yes	Yes	Yes
Constant	4.825***	3.584***	3.716*
	(1.472)	(0.686)	(1.776)
R-square	0.290	0.432	0.673
Observations	49	28	18

Impact of Sense of Belonging on Grades

Table 7 or table presents the results on the impact of sense of belonging on grades in calculus, physics, and programming. Some of the coefficient estimates across models have the desired magnitude and signs. I will focus on the results from Column 1 on calculus, as it has more significant estimates.

Sense of Belonging in Calculus Courses: Nearly all the measures of sense of belonging have a statistically significant effect on grades. For example, a student's grade in calculus is positively associated with the student agreement with the statement "Other students in the classroom share my personal interests." This suggests that the more a student feel a sense of belonging, the more likely is their average grade to increase. Similarly, a positive attitude toward earning an A or a B grade in calculus is strongly associated with higher grades.

Table 7: Effect of Sense of Belonging on Grades

	(1)	(2)	(3)
	Avg Grade Calculus	Avg Grade Physics	Avg Grade Programming
Other students share my personal interests	0.234**	0.0709	-0.194
	(0.0910)	(0.0840)	(0.153)
Can succeed in STEM	-0.332**	-0.259***	-0.394
	(0.129)	(0.0861)	(0.363)
Have a lot in common with peers	0.0140	0.149	0.0642
	(0.0998)	(0.101)	(0.182)
Comfortable asking a faculty for help - personal	-0.187**	-0.0696	-0.0541
	(0.0699)	(0.0426)	(0.178)
Comfortable seeking help from a teacher- academics	0.125	0.0124	0.0376
	(0.0806)	(0.0696)	(0.228)
Can Get A/B in Math	0.468***		
	(0.0721)		
Can Get A/B in Physics		0.419***	
		(0.0819)	
Can Get A/B in CS			0.514**
			(0.185)
Constant	1.107*	1.736***	2.958
	(0.562)	(0.597)	(1.649)
Demographic Variables	Yes	Yes	Yes
R-square	0.656	0.794	0.669
Observations	48	28	18

Comparable results were found for the statement "I feel comfortable asking a professor for help before and after class.", although not significant.

Surprisingly, the statement "I feel comfortable asking a professor for help with a personal problem" is negatively correlated with grades in calculus. A similar negative correlation was found with the statement “Someone like me can succeed in STEM.” It is not clear why these unexpected signs appear. One potential explanation is that as a student becomes too close to or too familiar with faculty members or when they become overconfident in their ability to succeed in STEM, they may be become somewhat complacent, which may hinder their ability to perform well.

The analysis highlights the complex relationship between students’ sense of belonging and their academic performance. While positive peer interactions and faculty support generally enhance grades, there are nuances to consider. Over-reliance on faculty for personal issues or excessive confidence in STEM success may negatively impact academic performance.

Impact of Study Habits Pre-College Preparation, Study Habits, and Sense of Belonging on Grades

I also introduce a comprehensive model that integrates all the main variables from equations [1] to [3]. This model is our preferred approach as it controls pre-college preparation, study hours, and sense of belonging. Research indicates that these variables significantly impact grades in STEM introductory courses[13]. Additionally, student characteristics have been accounted for in the model. The results are presented in Table 8.

Table 8: Study Habits Pre-College Preparation, Study Habits, and Sense of Belonging on Grades

	(1)	(2)
	Avg Grade Calculus	Avg Grade Physics
Preparation Calculus	0.192**	
	(0.0834)	
Preparation Physics		0.162***
		(0.0473)
Study (academic) hours	-0.111	0.00767
	(0.0747)	(0.0572)
Co-curricular hours	0.0344	0.0863
	(0.103)	(0.0607)
Hour relaxing	0.211*	0.0959
	(0.109)	(0.0754)
Other students share my personal interests	0.158	0.0715
	(0.140)	(0.118)
Can succeed in STEM	-0.0956	-0.120
	(0.170)	(0.101)
Have a lot in common with peers	0.202	0.248*
	(0.147)	(0.124)
Comfortable asking a faculty for help - personal	-0.158	-0.0640
	(0.0984)	(0.0652)

Comfortable seeking help from a teacher- academics	0.0377	-0.131
	(0.111)	(0.0985)
Constant	2.101	2.507***
	(1.568)	(0.779)
Demographic Variables	Yes	Yes
R-square	0.519	0.829
Observations	49	28

Model 1 presents findings for calculus grades, while Model 2 focuses on physics grades. Almost all coefficient estimates are consistent with the results from the individual models. For example, the model in column 1 shows that pre-college preparation in calculus is statistically and positively correlated with calculus grades (p-value < 0.05). The results also suggest a positive relationship between hours spent relaxing and calculus grades. Similarly, Model 2 consistently demonstrates that physics preparation is statistically and positively correlated with physics grades. However, the individual models outperform our preferred composite model.

Altogether, these findings underscore the significance of a balanced approach to academic preparation. While dedicated study hours are essential, a strong sense of belonging and engagement in non-academic activities also contribute substantially to academic success. This comprehensive model provides a nuanced understanding of the various factors influencing grades in STEM courses, highlighting the need for a holistic approach to student development.

Conclusion

Based on our findings, the pre-college level of preparation for calculus is positively associated with academic performance in the subject. Similar results were observed for programming courses. Notably, students majoring in Computer Science and female students tend to achieve higher grades with increased pre-college preparation in programming. This highlights the critical role of early academic preparation in setting a strong foundation for success in STEM fields.

Additionally, a sense of belonging significantly influences student grades. For instance, students' grades in calculus are positively correlated with having classmates who share their personal interests and feeling comfortable asking professors for help before and after school. This underscores the importance of fostering an inclusive and supportive classroom environment. Peer and faculty support, along with comfort in the classroom, are crucial components of this sense of belonging. Initiatives such as peer mentoring programs and faculty-student engagement activities could enhance student outcomes by fostering a sense of community and belonging.

Furthermore, our study highlights the complex relationship between study habits and academic performance. While study hours are crucial, excessive study can be detrimental to students' well-being and academic outcomes. Balancing study hours with non-academic activities and fostering a supportive environment can significantly enhance academic performance. These findings underscore the need for a holistic approach to student development, emphasizing the importance of balance and well-being alongside academic preparation.

The results of this study suggest that while students generally feel a sense of belonging in their academic environment, there are significant opportunities to enhance both peer and faculty support to foster deeper connections and greater engagement. Here are some areas of interventions that can create a more inclusive and supportive educational experience, ultimately leading to improved academic and emotional outcomes for students.

Peer Support

Building strong, positive relationships among students can significantly enhance their sense of belonging and overall academic performance. STEM institutions can implement peer mentorship programs, where more experienced students guide first-year students through their academic journey. Additionally, encouraging collaborative learning through group projects, study groups, and peer-led workshops can help students develop a sense of community and mutual support.

Faculty Support

Faculty support is equally crucial for student success. The active involvement of faculty members in students' academic lives can greatly enrich their learning experiences. Faculty can foster a supportive environment by being approachable, holding regular office hours, and providing timely and constructive feedback. Faculty engagement not only helps students grasp complex concepts but also provides them with mentorship and guidance, which are essential for academic achievement.

Inclusive Classroom Environment

Creating a comfortable and inclusive classroom environment is vital for fostering a sense of belonging. When students feel that their classroom is a safe and welcoming space, they are more likely to engage actively and express their ideas. STEM Institutions should promote diversity and inclusion by ensuring that all students feel represented and valued. This can be achieved through inclusive teaching practices, culturally responsive pedagogy, and creating opportunities for students from different backgrounds to interact and share their perspectives.

Early Faculty Interaction Programs

Introducing programs that facilitate early interactions between students and faculty can be highly beneficial. These programs can help students feel more comfortable and connected with their instructors, enhancing their overall academic experience. Benefits of such programs include increased Comfort and Confidence and stronger Faculty-Student Relationships. Students who feel connected to their faculty are more likely to participate actively in class discussions, seek assistance when needed, and engage in academic activities outside the classroom.

One limitation of the study is the small sample size of minority groups, which prevents a more detailed empirical analysis by race, first-generation status, and economically disadvantaged students.

References

1 Clayton, A. B., & Worsham, R. E. (2024). Preparing Students for Postsecondary Success: The Effects of College Advising on College Readiness. Innovative Higher Education, 49(1), 1-24.

2 2 Vedogbeton, H., Brown, C., Somasse, G. B., & Krueger, R. (2023, June). Improving the Experiences and Retention of Black Students in STEM Education. In 2023 ASEE Annual Conference & Exposition.

3 Kurlaender, M., Reed, S., & Hurtt, A. (2019). Improving College Readiness: A Research Summary and Implications for Practice. *Policy Analysis for California Education, PACE*.

4 Gottfried, M. A., & Bozick, R. (2016). Supporting the STEM pipeline: Linking applied STEM course-taking in high school to declaring a STEM major in college. *Education Finance and Policy*, *11*(2), 177-202.

5 Engberg, M. E., & Wolniak, G. C. (2009). Navigating disparate pathways to college: Examining the conditional effects of race on enrollment decisions. *Teachers College Record*, *111*(9), 2255-2279.

6 McCormick, A. C., Kinzie, J., & Gonyea, R. M. (2013). Student engagement: Bridging research and practice to improve the quality of undergraduate education. In *Higher Education: Handbook of Theory and Research: Volume 28* (pp. 47-92). Dordrecht: Springer Netherlands.

7 Trolian, T. L., Jach, E. A., Hanson, J. M., & Pascarella, E. T. (2016). Influencing academic motivation: The effects of student–faculty interaction. *Journal of College Student Development*, *57*(7), 810-826.

8 Rands, M. L., & Gansemer-Topf, A. M. (2017). The Room Itself Is Active: How Classroom Design Impacts Student Engagement. *Journal of Learning Spaces*, *6*(1), 26-33.

[9] Asher, S. R., & Weeks, M. S. (2012). Social relationships, academic engagement, and well-being in college: Findings from the Duke social relationships project. *Durham, NC: Duke University*.

10 Liu, M. (2022). The Relationship between Students' Study Time and Academic Performance and its Practical Significance. BCP Edu. Psychol, 7, 412-415.

11 Teuber, M., Leyhr, D., & Sudeck, G. (2024). Physical activity improves stress load, recovery, and academic performance-related parameters among university students: a longitudinal study on daily level. BMC Public Health, 24(1), 598.

12 Nonis, S. A., & Hudson, G. I. (2006). Academic performance of college students: Influence of time spent studying and working. Journal of education for business, 81(3), 151-159.

[13] Credé, M., & Kuncel, N. R. (2008). Study habits, skills, and attitudes: The third pillar supporting collegiate academic performance. *Perspectives on psychological science*, *3*(6), 425-453.

Appendices

Appendix 1-Demographics

Variables	Observations	Mean	Std. Dev.
Gender			
Male	109	0.56	0.50
Female	109	0.34	0.48
Non-binary	109	0.10	0.30
Race			
White	124	0.65	0.44
Black	124	0.04	0.20
Hispanic	124	0.04	0.20
Asian	124	0.08	0.27
Two or more races	124	0.19	0.39
Other			
First generation	124	0.14	0.35
Pell	124	0.05	0.22

Appendix 2- Preparation for Introductory Courses by Gender, Race, and Major

	Female			***Male***		
	Observation	**Mean**	**Std. Dev.**	**Observation**	**Mean**	**Std. Dev.**
Calculus	36	4.42	1.59	71	5.01	1.76
Physics	30	4.3	1.74	52	5.00	1.41
Programming	28	3.04	1.77	58	4.48	1.91
	White			***Minority***		
	Observation	**Mean**	**Std. Dev.**	**Observation**	**Mean**	**Std. Dev.**
Calculus	79	4.76	1.76	20	5.35	1.42
Physics	60	4.63	1.57	16	5.00	1.55
Programming	65	4.12	2.01	15	3.73	1.62
	Computer Science Major			***Other Major***		
	Observation	**Mean**	**Std. Dev.**	**Observation**	**Mean**	**Std. Dev.**
Calculus	35	4.6	1.9	87	4.79	1.67
Physics	16	4.88	1.02	79	4.76	1.63
Programming	35	4.89	1.71	62	3.42	1.91

Appendix 3-Hours Spent per Week on Academic and non-academic Activities by Gender, Race, Major

Panel A	***Female***			***Male***		
Variables	**Observation**	**Mean**	**Std. Dev.**	**Observation**	**Mean**	**Std. Dev.**
Preparation for Class	37	3.41	1.14	72	3.82	1.70
Co-curricular Activity	37	1.57	1.17	72	1.40	1.19
Work for pay on campus	37	0.24	0.49	72	0.11	0.46
Work for pay of campus	37	0.41	1.34	72	0.46	1.42
Volunteering	37	0.22	0.42	72	0.22	0.56
Relaxing	37	2.27	1.3	72	2.71	1.56
Commuting	37	0.51	0.61	72	0.40	0.64
Panel B	***White***			**Minority**		
Variables	**Observation**	**Mean**	**Std. Dev.**	**Observation**	**Mean**	**Std. Dev.**
Preparation for Class	81	3.63	1.5	20	4.15	1.63
Co-curricular Activity	81	1.41	1.14	20	1.50	1.43
Work for pay on campus	81	0.05	0.22	20	0.45	0.83
Work for pay of campus	81	0.4	1.2	20	0.80	2.17
Volunteering	81	0.23	0.55	20	0.20	0.41
Relaxing	81	2.7	1.54	20	2.10	1.33
Commuting	*81*	*0.48*	*0.67*	*20*	*0.35*	*0.489*
	Computer Science			**Other Major**		
Variables	**Observation**	**Mean**	**Std. Dev.**	**Observation**	**Mean**	**Std. Dev.**
Preparation for Class	35	3.43	1.72	89	3.67	1.49
Co-curricular Activity	35	1.57	1.33	89	1.48	1.21
Work for pay on campus	35	0.03	0.17	89	0.27	0.62
Work for pay of campus	35	0.31	1.02	89	0.49	1.45
Volunteering	35	0.11	0.32	89	0.30	0.61
Relaxing	35	2.43	1.56	89	2.58	1.42
Commuting	*35*	0.34	0.54	89	0.55	0.69

Appendix 4- Sense of Belonging Measures

Panel A	**Peer Support**				
Variables	**Observation**	**Mean**	**Std. Dev.**	**Min**	**Max**
Peer Help with note	118	5.14	1.58	1	7
Study with peer outside of class	118	4.47	2.16	1	7
Contact peer outside of class	118	5.19	1.58	1	7
Developed Relationship with peer	118	4.77	1.71	1	7
Panel B	***Faculty Support***				
Variables	**Observation**	**Mean**	**Std. Dev.**	**Min**	**Max**
Faculty can help me if I need help	118	5.5	1.38	2	7
Faculty try to understand my problem	118	5.03	1.25	1	7
Comfort seeking help before and after class	118	5.42	1.29	2	7
Comfort asking faculty help with personal problem	118	3.64	1.72	1	7
Panel C	***Class Comfort***				
Variables	**Observation**	**Mean**	**Std. Dev.**	**Min**	**Max**
Comfort contributing to class discussion	110	5.17	1.48	1	7
Comfort asking question in class	110	4.96	1.54	1	7
Comfort volunteering idea in class	110	4.76	1.66	1	7
Comfort Speaking in class	110	4.45	1.63	1	7
Panel D	***Additional Measures of Sense of Belonging***				
Variables	**Observation**	**Mean**	**Std. Dev.**	**Min**	**Max**
Relate to peer in the classroom	108	4.71	1.47	1	7
A lot in common with classmates	110	4.67	1.39	1	7
Classmates share personal interests	109	4.66	1.47	1	7
Someone like me can succeed in STEM	110	6.08	1.01	1	7