

Predictive Models for Initial College Math Course and Major Selection Based on High School Institutional Factors



Dr. Eliza Gallagher



Dr. Christy Brown



Dr. Kris Frady

Clemson University



This work was supported by the National Science Foundation under Grant no. 1744497. Additional funding was provided by the College of Education, the College of Engineering Computing and Applied Sciences, the University Professional Internship and Co-op (UPIC) program and the Creative Inquiry (CI) program at Clemson University. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation, UPIC, or Clemson University.

1

SC: SUPPORTED NSF INCLUDES Project



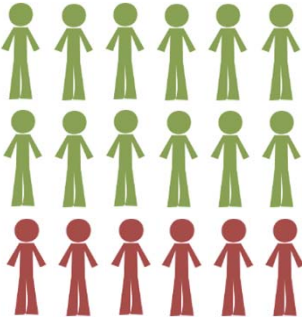
Statewide Coalition:
Supporting Underrepresented
Populations in Precalculus through
Organizational Redesign Toward
Engineering Diversity

SC: SUPPORTED

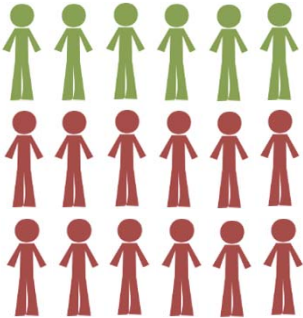
2

SC: SUPPORTED Project Goals

KEY FACT: INITIAL MATH COURSE PLACEMENT MATTERS



Calc I or Higher Graduation Rate



Below Calculus Graduation Rate

Engineering students initially placed in calculus or higher persist in degree completion at nearly twice the rate of those placed below calculus.

GOAL: Increase number of STEM students entering college calculus-ready.

3/1/2019
SCEPUR 2019 Conference
3

3

Data Collection

Coalition schools: 16 technical colleges in SC system, CU, USC, Citadel, SCSU

Data collected from the 20 coalition schools for students in these programs:

- Engineering
- Engineering Technologies
- Mathematics & Statistics
- Physical Science
- Science Technologies
- Computer & Information Sciences
- Communications Technologies
- Business, Management & Marketing
- Precision Production
- Machine & Repair Technologies

Variables recorded (first-year students only):

- Instructional program
- High school of graduation
- First math course
- AP scores

Students without AP credit and no first math classified below calculus

Total number of individual data points: 21,656

- 8,625 from 4-year campuses
- 4,009 in-state/4-year
- 13,031 from technical colleges
- 10,727 in-state/technical

3/1/2019
SCEPUR 2019 Conference
4

4

Research Questions

What high school institutional factors are significant predictors of the rate of:

- initial placement **at or above Calculus I** versus **below Calculus I** for students at both **two-year and four-year** institutions?
- initial placement **at or above Calculus I** versus **below Calculus I** for students at **two-year** institutions?
- initial placement in **college algebra, trigonometry, or precalculus** versus **developmental math or basic algebra** for students at both **two-year and four-year** institutions?
- students choosing **engineering over a related major** at both **two-year and four-year** institutions?
- students choosing **engineering over a related major** at **two-year** schools?
- students choosing **engineering over a related major** at **four-year** schools?

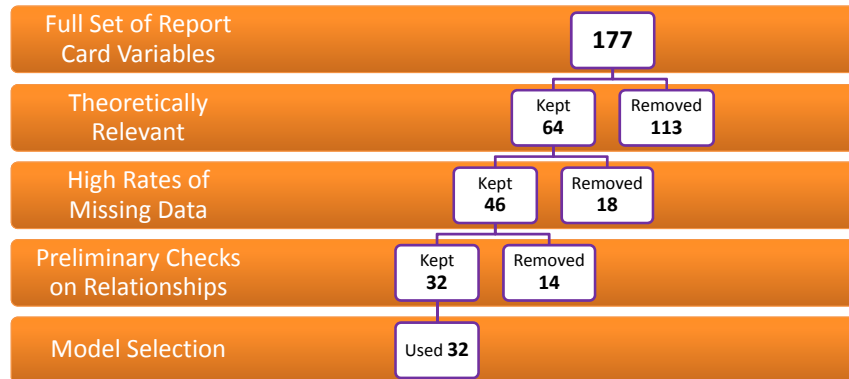
3/1/2019

SCEPUR 2019 Conference

5

5

High School Institutional Factors



3/1/2019

SCEPUR 2019 Conference

6

6

High School Institutional Factors

<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>gkto12 (enrollment)</td></tr> <tr><td style="border: 2px solid red;">poverty (% homeless, in foster care, and on aide)</td></tr> <tr><td>C4 (student attendance rate)</td></tr> <tr><td>C11 (% of students suspended/expelled)</td></tr> <tr><td>C6 (% of students served by gifted and talented)</td></tr> <tr><td>C3 (% of students retained)</td></tr> <tr><td>C12 (% of students enrolled in an AP/IB course)</td></tr> <tr><td>cFAF (number of seniors completing FAFSA forms)</td></tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>A16_EngAvg (average English ACT)</td></tr> <tr><td>A16_MatAvg (average Math ACT)</td></tr> <tr><td>A16_ComAvg (average composite ACT)</td></tr> <tr><td>EOC16_Math (Algebra I EOC Test pass rate)</td></tr> <tr><td>EOC16_Eng (English I EOC Test pass rate)</td></tr> <tr><td>EOC16_Bio (Biology I EOC Test pass rate)</td></tr> <tr><td>EOC16_Hist (US History EOC Test pass rate)</td></tr> <tr><td>EOC16_All (EOC Test pass rate all subjects)</td></tr> </table>	gkto12 (enrollment)	poverty (% homeless, in foster care, and on aide)	C4 (student attendance rate)	C11 (% of students suspended/expelled)	C6 (% of students served by gifted and talented)	C3 (% of students retained)	C12 (% of students enrolled in an AP/IB course)	cFAF (number of seniors completing FAFSA forms)	A16_EngAvg (average English ACT)	A16_MatAvg (average Math ACT)	A16_ComAvg (average composite ACT)	EOC16_Math (Algebra I EOC Test pass rate)	EOC16_Eng (English I EOC Test pass rate)	EOC16_Bio (Biology I EOC Test pass rate)	EOC16_Hist (US History EOC Test pass rate)	EOC16_All (EOC Test pass rate all subjects)	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>GRADRATE16 (four year graduation rate)</td></tr> <tr><td>LIFE (% of seniors eligible for LIFE scholarship)</td></tr> <tr><td>CFR_College (% of graduates in 2 or 4 year college)</td></tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>C23 (% of teachers with advanced degrees)</td></tr> <tr><td>C24 (% of teachers on continuing contract)</td></tr> <tr><td>C27 (% of teachers returning from previous year)</td></tr> <tr><td>C28 (teacher attendance rate)</td></tr> <tr><td>C29 (average teacher salary)</td></tr> <tr><td>C30 (professional development days per teacher)</td></tr> <tr><td>C32 (student-teacher ratio)</td></tr> <tr><td>C33 (prime instructional time)</td></tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>ST4 (% of teachers satisfied w/ learning environment)</td></tr> <tr><td>ST5 (% of students satisfied w/ learning environment)</td></tr> <tr><td>ST7 (% of teachers satisfied w/ physical environment)</td></tr> <tr><td>ST8 (% of students satisfied w/ physical environment)</td></tr> <tr><td>ST10 (% of teachers satisfied w/ school-home relations)</td></tr> <tr><td>ST11 (% of students satisfied w/ school-home relations)</td></tr> </table>	GRADRATE16 (four year graduation rate)	LIFE (% of seniors eligible for LIFE scholarship)	CFR_College (% of graduates in 2 or 4 year college)	C23 (% of teachers with advanced degrees)	C24 (% of teachers on continuing contract)	C27 (% of teachers returning from previous year)	C28 (teacher attendance rate)	C29 (average teacher salary)	C30 (professional development days per teacher)	C32 (student-teacher ratio)	C33 (prime instructional time)	ST4 (% of teachers satisfied w/ learning environment)	ST5 (% of students satisfied w/ learning environment)	ST7 (% of teachers satisfied w/ physical environment)	ST8 (% of students satisfied w/ physical environment)	ST10 (% of teachers satisfied w/ school-home relations)	ST11 (% of students satisfied w/ school-home relations)
gkto12 (enrollment)																																		
poverty (% homeless, in foster care, and on aide)																																		
C4 (student attendance rate)																																		
C11 (% of students suspended/expelled)																																		
C6 (% of students served by gifted and talented)																																		
C3 (% of students retained)																																		
C12 (% of students enrolled in an AP/IB course)																																		
cFAF (number of seniors completing FAFSA forms)																																		
A16_EngAvg (average English ACT)																																		
A16_MatAvg (average Math ACT)																																		
A16_ComAvg (average composite ACT)																																		
EOC16_Math (Algebra I EOC Test pass rate)																																		
EOC16_Eng (English I EOC Test pass rate)																																		
EOC16_Bio (Biology I EOC Test pass rate)																																		
EOC16_Hist (US History EOC Test pass rate)																																		
EOC16_All (EOC Test pass rate all subjects)																																		
GRADRATE16 (four year graduation rate)																																		
LIFE (% of seniors eligible for LIFE scholarship)																																		
CFR_College (% of graduates in 2 or 4 year college)																																		
C23 (% of teachers with advanced degrees)																																		
C24 (% of teachers on continuing contract)																																		
C27 (% of teachers returning from previous year)																																		
C28 (teacher attendance rate)																																		
C29 (average teacher salary)																																		
C30 (professional development days per teacher)																																		
C32 (student-teacher ratio)																																		
C33 (prime instructional time)																																		
ST4 (% of teachers satisfied w/ learning environment)																																		
ST5 (% of students satisfied w/ learning environment)																																		
ST7 (% of teachers satisfied w/ physical environment)																																		
ST8 (% of students satisfied w/ physical environment)																																		
ST10 (% of teachers satisfied w/ school-home relations)																																		
ST11 (% of students satisfied w/ school-home relations)																																		

3/1/2019
SCEPUR 2019 Conference
7

7

High School Institutional Factors

School poverty index (percentage of students in a school that are transient, in foster care, homeless, or have been Medicaid-eligible or qualified for SNAP services in the last 3 years) was highly correlated with nearly all of the predictor variables, hence models with school poverty index as the only predictor of a student's math placement were fit.

Variable	Predicting Calculus Placement ($N = 3,634$)			Predicting Placement into a College Math below Calculus ($N = 1,515$)		
	B	$SE\ B$	p -value	B	$SE\ B$	p -value
Intercept	1.084	0.112	<.0001	0.724	0.173	<.0001
Poverty	-0.040	0.002	<.0001	-0.018	0.003	<.0001

3/1/2019
SCEPUR 2019 Conference
8

8

High School Institutional Factors

<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>gkto12 (enrollment)</td></tr> <tr><td>C4 (student attendance rate)</td></tr> <tr><td>C11 (% of students suspended/expelled)</td></tr> <tr><td>C6 (% of students served by gifted and talented)</td></tr> <tr><td>C3 (% of students retained)</td></tr> <tr><td>C12 (% of students enrolled in an AP/IB course)</td></tr> <tr><td>cFAF (number of seniors completing FAFSA forms)</td></tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>A16_EngAvg (average English ACT)</td></tr> <tr><td>A16_MatAvg (average Math ACT)</td></tr> <tr><td>A16_ComAvg (average composite ACT)</td></tr> <tr><td>EOC16_Math (Algebra I EOC Test pass rate)</td></tr> <tr><td>EOC16_Eng (English I EOC Test pass rate)</td></tr> <tr><td>EOC16_Bio (Biology I EOC Test pass rate)</td></tr> <tr><td>EOC16_Hist (US History EOC Test pass rate)</td></tr> <tr><td>EOC16_All (EOC Test pass rate all subjects)</td></tr> </table>	gkto12 (enrollment)	C4 (student attendance rate)	C11 (% of students suspended/expelled)	C6 (% of students served by gifted and talented)	C3 (% of students retained)	C12 (% of students enrolled in an AP/IB course)	cFAF (number of seniors completing FAFSA forms)	A16_EngAvg (average English ACT)	A16_MatAvg (average Math ACT)	A16_ComAvg (average composite ACT)	EOC16_Math (Algebra I EOC Test pass rate)	EOC16_Eng (English I EOC Test pass rate)	EOC16_Bio (Biology I EOC Test pass rate)	EOC16_Hist (US History EOC Test pass rate)	EOC16_All (EOC Test pass rate all subjects)	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>GRADRATE16 (four year graduation rate)</td></tr> <tr><td>LIFE (% of seniors eligible for LIFE scholarship)</td></tr> <tr><td>CFR_College (% of graduates in 2 or 4 year college)</td></tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>C23 (% of teachers with advanced degrees)</td></tr> <tr><td>C24 (% of teachers on continuing contract)</td></tr> <tr><td>C27 (% of teachers returning from previous year)</td></tr> <tr><td>C28 (teacher attendance rate)</td></tr> <tr><td>C29 (average teacher salary)</td></tr> <tr><td>C30 (professional development days per teacher)</td></tr> <tr><td>C32 (student-teacher ratio)</td></tr> <tr><td>C33 (prime instructional time)</td></tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>ST4 (% of teachers satisfied w/ learning environment)</td></tr> <tr><td>ST5 (% of students satisfied w/ learning environment)</td></tr> <tr><td>ST7 (% of teachers satisfied w/ physical environment)</td></tr> <tr><td>ST8 (% of students satisfied w/ physical environment)</td></tr> <tr><td>ST10 (% of teachers satisfied w/ school-home relations)</td></tr> <tr><td>ST11 (% of students satisfied w/ school-home relations)</td></tr> </table>	GRADRATE16 (four year graduation rate)	LIFE (% of seniors eligible for LIFE scholarship)	CFR_College (% of graduates in 2 or 4 year college)	C23 (% of teachers with advanced degrees)	C24 (% of teachers on continuing contract)	C27 (% of teachers returning from previous year)	C28 (teacher attendance rate)	C29 (average teacher salary)	C30 (professional development days per teacher)	C32 (student-teacher ratio)	C33 (prime instructional time)	ST4 (% of teachers satisfied w/ learning environment)	ST5 (% of students satisfied w/ learning environment)	ST7 (% of teachers satisfied w/ physical environment)	ST8 (% of students satisfied w/ physical environment)	ST10 (% of teachers satisfied w/ school-home relations)	ST11 (% of students satisfied w/ school-home relations)
gkto12 (enrollment)																																	
C4 (student attendance rate)																																	
C11 (% of students suspended/expelled)																																	
C6 (% of students served by gifted and talented)																																	
C3 (% of students retained)																																	
C12 (% of students enrolled in an AP/IB course)																																	
cFAF (number of seniors completing FAFSA forms)																																	
A16_EngAvg (average English ACT)																																	
A16_MatAvg (average Math ACT)																																	
A16_ComAvg (average composite ACT)																																	
EOC16_Math (Algebra I EOC Test pass rate)																																	
EOC16_Eng (English I EOC Test pass rate)																																	
EOC16_Bio (Biology I EOC Test pass rate)																																	
EOC16_Hist (US History EOC Test pass rate)																																	
EOC16_All (EOC Test pass rate all subjects)																																	
GRADRATE16 (four year graduation rate)																																	
LIFE (% of seniors eligible for LIFE scholarship)																																	
CFR_College (% of graduates in 2 or 4 year college)																																	
C23 (% of teachers with advanced degrees)																																	
C24 (% of teachers on continuing contract)																																	
C27 (% of teachers returning from previous year)																																	
C28 (teacher attendance rate)																																	
C29 (average teacher salary)																																	
C30 (professional development days per teacher)																																	
C32 (student-teacher ratio)																																	
C33 (prime instructional time)																																	
ST4 (% of teachers satisfied w/ learning environment)																																	
ST5 (% of students satisfied w/ learning environment)																																	
ST7 (% of teachers satisfied w/ physical environment)																																	
ST8 (% of students satisfied w/ physical environment)																																	
ST10 (% of teachers satisfied w/ school-home relations)																																	
ST11 (% of students satisfied w/ school-home relations)																																	

3/1/2019
SCEPUR 2019 Conference
9

9

High School Institutional Factors

<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>gkto12 (enrollment)</td></tr> <tr><td>C4 (student attendance rate)</td></tr> <tr><td>C11 (% of students suspended/expelled)</td></tr> <tr><td>C6 (% of students served by gifted and talented)</td></tr> <tr><td>C3 (% of students retained)</td></tr> <tr><td>C12 (% of students enrolled in an AP/IB course)</td></tr> <tr><td>cFAF (number of seniors completing FAFSA forms)</td></tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>A16_EngAvg (average English ACT)</td></tr> <tr><td>A16_MatAvg (average Math ACT)</td></tr> <tr><td>A16_ComAvg (average composite ACT)</td></tr> <tr><td>EOC16_Math (Algebra I EOC Test pass rate)</td></tr> <tr><td>EOC16_Eng (English I EOC Test pass rate)</td></tr> <tr><td>EOC16_Bio (Biology I EOC Test pass rate)</td></tr> <tr><td>EOC16_Hist (US History EOC Test pass rate)</td></tr> <tr><td>EOC16_All (EOC Test pass rate all subjects)</td></tr> </table>	gkto12 (enrollment)	C4 (student attendance rate)	C11 (% of students suspended/expelled)	C6 (% of students served by gifted and talented)	C3 (% of students retained)	C12 (% of students enrolled in an AP/IB course)	cFAF (number of seniors completing FAFSA forms)	A16_EngAvg (average English ACT)	A16_MatAvg (average Math ACT)	A16_ComAvg (average composite ACT)	EOC16_Math (Algebra I EOC Test pass rate)	EOC16_Eng (English I EOC Test pass rate)	EOC16_Bio (Biology I EOC Test pass rate)	EOC16_Hist (US History EOC Test pass rate)	EOC16_All (EOC Test pass rate all subjects)	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>GRADRATE16 (four year graduation rate)</td></tr> <tr><td>LIFE (% of seniors eligible for LIFE scholarship)</td></tr> <tr><td>CFR_College (% of graduates in 2 or 4 year college)</td></tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>C23 (% of teachers with advanced degrees)</td></tr> <tr><td>C24 (% of teachers on continuing contract)</td></tr> <tr><td>C27 (% of teachers returning from previous year)</td></tr> <tr><td>C28 (teacher attendance rate)</td></tr> <tr><td>C29 (average teacher salary)</td></tr> <tr><td>C30 (professional development days per teacher)</td></tr> <tr><td>C32 (student-teacher ratio)</td></tr> <tr><td>C33 (prime instructional time)</td></tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>ST4 (% of teachers satisfied w/ learning environment)</td></tr> <tr><td>ST5 (% of students satisfied w/ learning environment)</td></tr> <tr><td>ST7 (% of teachers satisfied w/ physical environment)</td></tr> <tr><td>ST8 (% of students satisfied w/ physical environment)</td></tr> <tr><td>ST10 (% of teachers satisfied w/ school-home relations)</td></tr> <tr><td>ST11 (% of students satisfied w/ school-home relations)</td></tr> </table>	GRADRATE16 (four year graduation rate)	LIFE (% of seniors eligible for LIFE scholarship)	CFR_College (% of graduates in 2 or 4 year college)	C23 (% of teachers with advanced degrees)	C24 (% of teachers on continuing contract)	C27 (% of teachers returning from previous year)	C28 (teacher attendance rate)	C29 (average teacher salary)	C30 (professional development days per teacher)	C32 (student-teacher ratio)	C33 (prime instructional time)	ST4 (% of teachers satisfied w/ learning environment)	ST5 (% of students satisfied w/ learning environment)	ST7 (% of teachers satisfied w/ physical environment)	ST8 (% of students satisfied w/ physical environment)	ST10 (% of teachers satisfied w/ school-home relations)	ST11 (% of students satisfied w/ school-home relations)
gkto12 (enrollment)																																	
C4 (student attendance rate)																																	
C11 (% of students suspended/expelled)																																	
C6 (% of students served by gifted and talented)																																	
C3 (% of students retained)																																	
C12 (% of students enrolled in an AP/IB course)																																	
cFAF (number of seniors completing FAFSA forms)																																	
A16_EngAvg (average English ACT)																																	
A16_MatAvg (average Math ACT)																																	
A16_ComAvg (average composite ACT)																																	
EOC16_Math (Algebra I EOC Test pass rate)																																	
EOC16_Eng (English I EOC Test pass rate)																																	
EOC16_Bio (Biology I EOC Test pass rate)																																	
EOC16_Hist (US History EOC Test pass rate)																																	
EOC16_All (EOC Test pass rate all subjects)																																	
GRADRATE16 (four year graduation rate)																																	
LIFE (% of seniors eligible for LIFE scholarship)																																	
CFR_College (% of graduates in 2 or 4 year college)																																	
C23 (% of teachers with advanced degrees)																																	
C24 (% of teachers on continuing contract)																																	
C27 (% of teachers returning from previous year)																																	
C28 (teacher attendance rate)																																	
C29 (average teacher salary)																																	
C30 (professional development days per teacher)																																	
C32 (student-teacher ratio)																																	
C33 (prime instructional time)																																	
ST4 (% of teachers satisfied w/ learning environment)																																	
ST5 (% of students satisfied w/ learning environment)																																	
ST7 (% of teachers satisfied w/ physical environment)																																	
ST8 (% of students satisfied w/ physical environment)																																	
ST10 (% of teachers satisfied w/ school-home relations)																																	
ST11 (% of students satisfied w/ school-home relations)																																	

3/1/2019
SCEPUR 2019 Conference
10

10

Model Results

Variable	Statistical Significance				
	Model 1a	Model 1b	Model 2a	Model 2b	Model 2c
A16_MatAvg (average Math ACT score)	***	**			
CFR_College (percent of 2015 graduating class enrolled in 2 or 4 year college)	**		**		
C6 (percentage of students served by gifted and talented program)	**				
cFAF (number of seniors who have completed FAFSA forms)	**				
C12 (percent enrolled in an AP/IB course)	***				
Gkto12 (total student enrollment)		***			
C3 (percentage of students retained in 2016)		*			**
C4 (student attendance rate)		**			*
C27 (percentage of teachers returning from previous year)		**			
GRADRATE16 (school four-year graduation rate in 2016)			*	*	
EOC16_All (EOC Test pass rate across all subjects)			***		
C24 (percentage of teachers on continuing contract)					*

*indicates $p < .05$; **indicates $p < .01$; ***indicates $p < .0001$; shading indicates NEGATIVE coefficient

- Model 1a:** At or above Calc I versus below Calc I for two-year and four-year
- Model 1b:** College algebra/trig/precalc versus developmental math/basic algebra for two-year and four-year
- Model 2a:** Engineering over a related major at two-year and four-year
- Model 2b:** Engineering over a related major at two-year
- Model 2c:** Engineering over a related major at four-year