

A National Model for Engineering Mathematics Education: Longitudinal Impact at Wright State University

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<http://www.cecs.wright.edu/engmath/>

Motivation and Objective

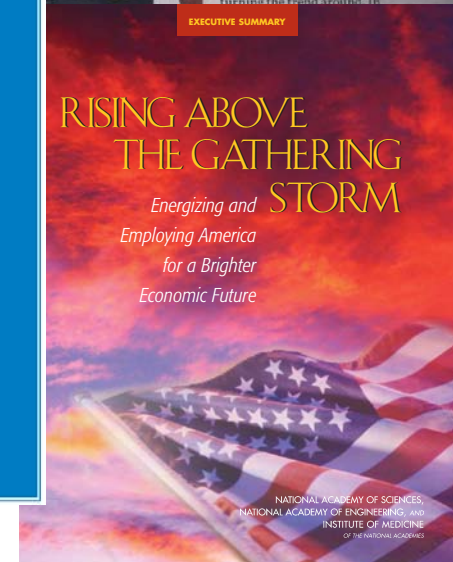
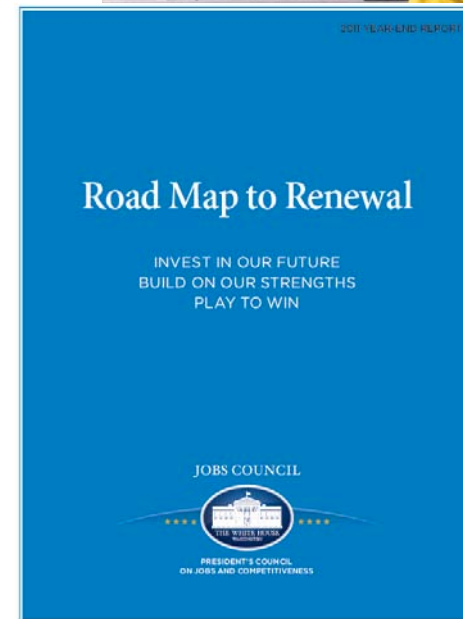
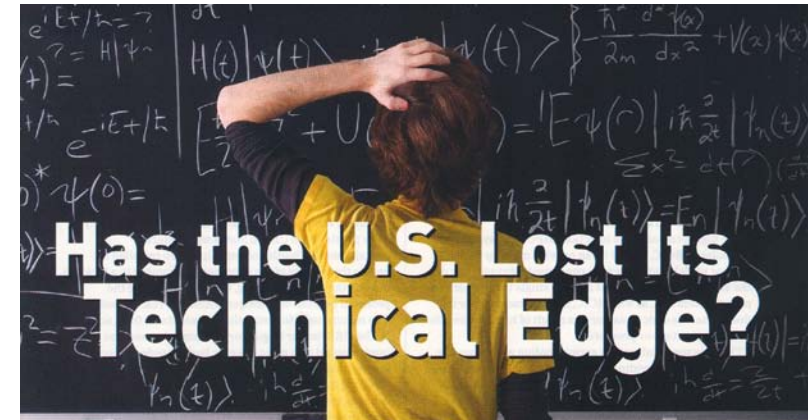


Motivation:

- ❑ The inability of incoming students to advance past the traditional freshman calculus sequence remains a primary cause of attrition in engineering programs across the country.
- ❑ Meanwhile, our nation's leaders are calling for 10,000 more engineers per year. We can far exceed this number by simply addressing curricular barriers and graduating more of the students we already have.

Objective:

To increase student retention, motivation and success in engineering through *application-driven, just-in-time, engineering* math instruction



EGR 101: Introductory Mathematics for Engineering Applications



❑ Course Topics

- Linear & Quadratic Equations
- Trigonometry
- Vectors and Complex Numbers
- Sinusoids and Harmonic Signals
- Systems of Equations and Matrices
- Basics of Differentiation
- Basics of Integration
- Differential Eqns. W/Const. Coeffs.



- ❑ All topics driven by *engineering applications* taken directly from core engineering courses
- ❑ Lectures reinforced by hands-on laboratory and recitation components including a thorough integration with MATLAB
- ❑ Replaces traditional math prerequisites for core sophomore-level engineering courses – *effectively uncorking the calculus bottleneck*

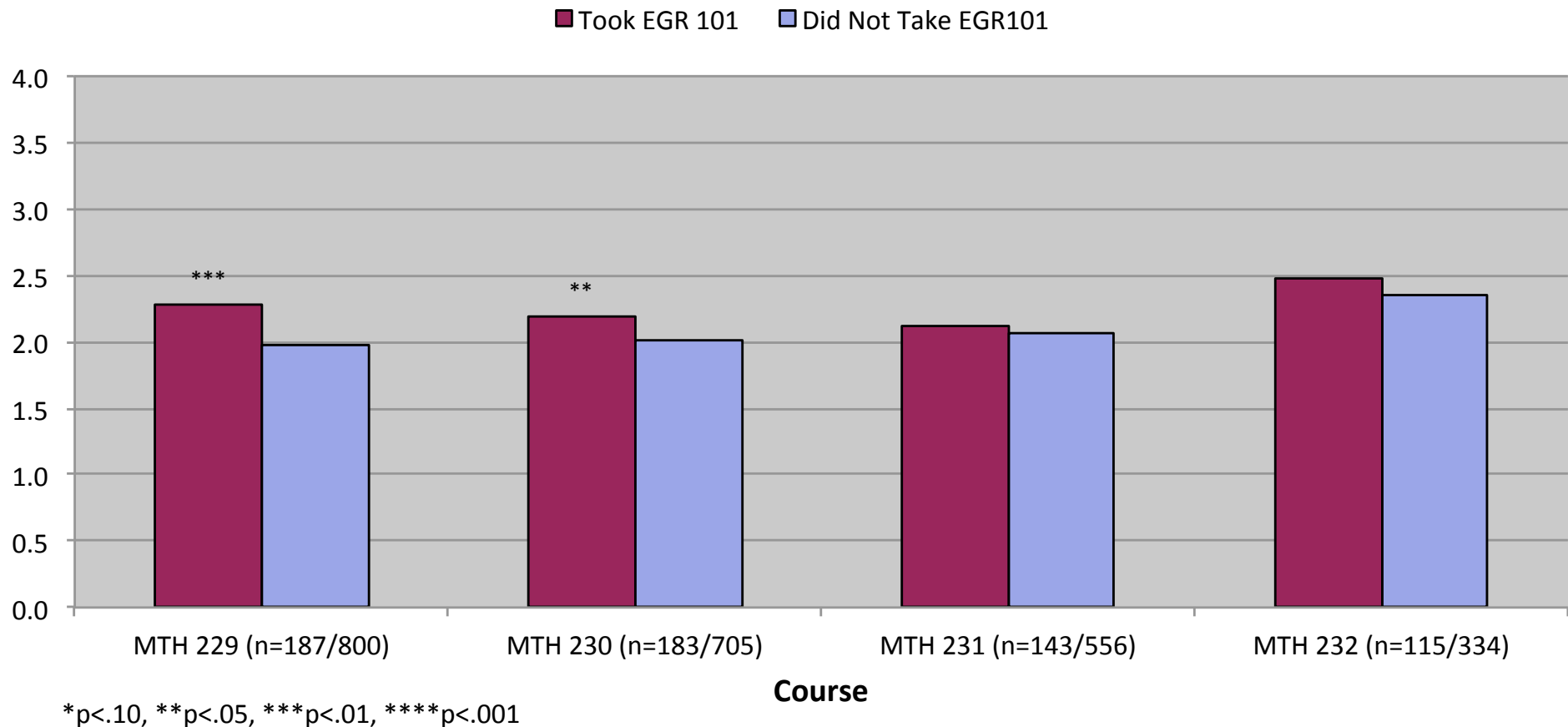
Student Comments on EGR 101



- ❑ “This course has really helped me. I was thinking of dropping engineering, but because of this course I am sticking with it...”
- ❑ “Being able to put calculus to actual engineering problems helps a lot for me. I didn’t understand it in high school, but being able to imagine or see it in an actual problem helped greatly.”
- ❑ “I enjoyed the class because it focused more on application to real world problems rather than just numbers. The lectures based on example problems followed up by recitation created a very good learning environment for me.”

Longitudinal Study: Student Performance in Calculus

Impact of EGR 101 on Student Performance in Calculus All DFHS Students Entering Fall 2000-Fall 2006

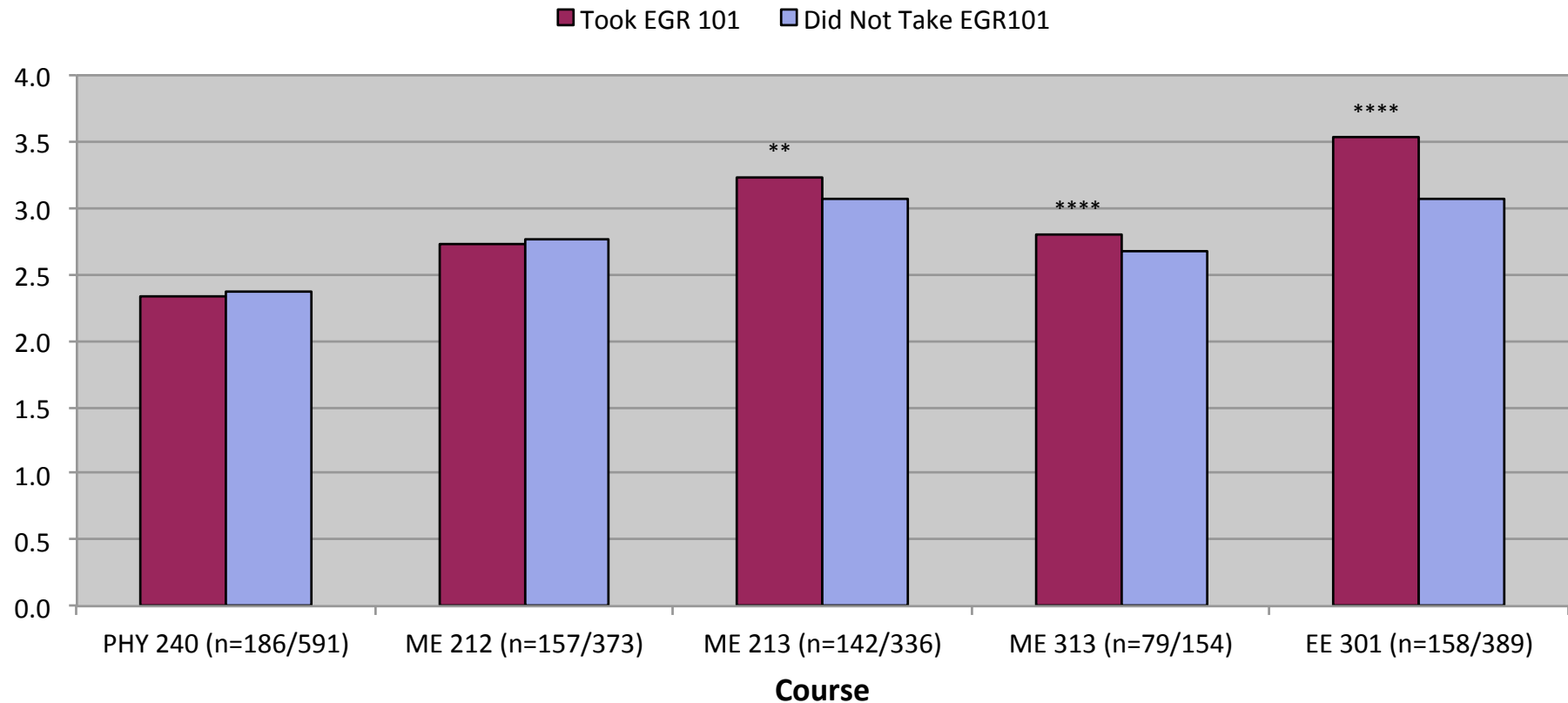


- Students who took EGR 101 had a statistically significant advantage in their first two calculus courses

Longitudinal Study: Student Performance in Engineering



Impact of EGR 101 on Student Performance in Engineering Courses All DFHS Students Entering Fall 2000-Fall 2006



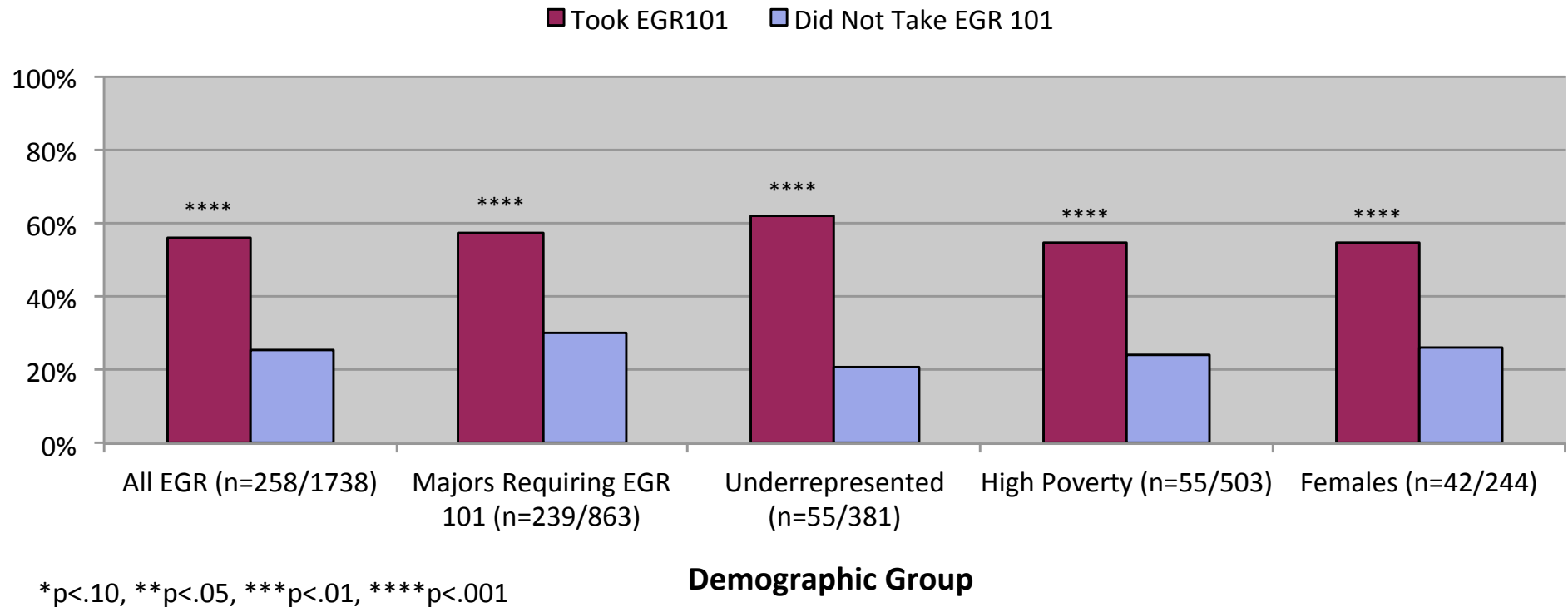
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- ❑ Students who took EGR 101 had a statistically significant advantage in Dynamics, Strength of Materials and Electric Circuits. No significant difference in Physics I or Statics.

Longitudinal Study: Ultimate Graduation Rates



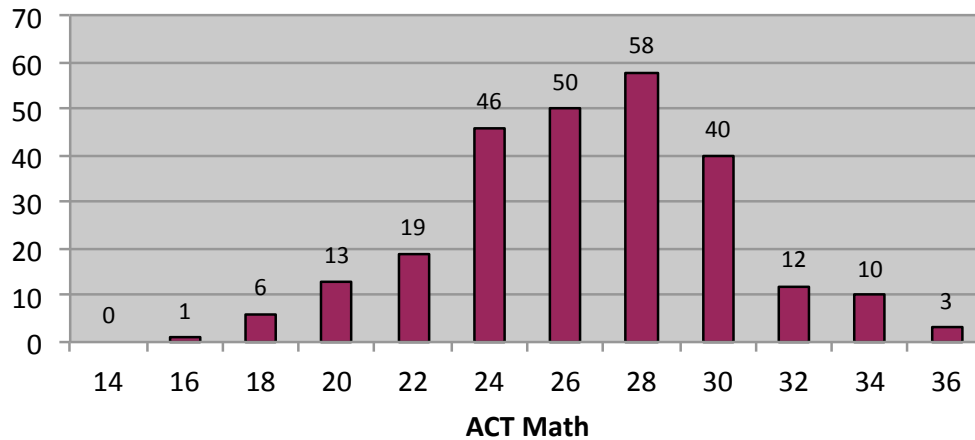
Impact of EGR 101 on CECS Graduation Rates All DFHS Students Entering Fall 2000-Fall 2006 Earning CECS Degree



- ❑ Students who took EGR 101 earned CECS degrees at more than *double* the rate of those who did not. For underrepresented students, the difference was nearly a factor of *three*...

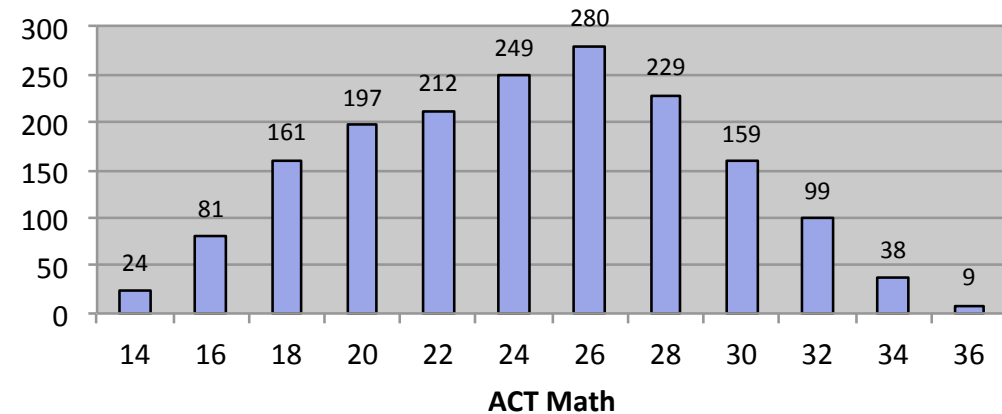
Longitudinal Study: Are the Populations Comparable?

Took EGR 101 (n=258)



$$(\bar{x}, s_x) = (26.1, 3.67)$$

Did Not Take EGR 101 (n=1738)

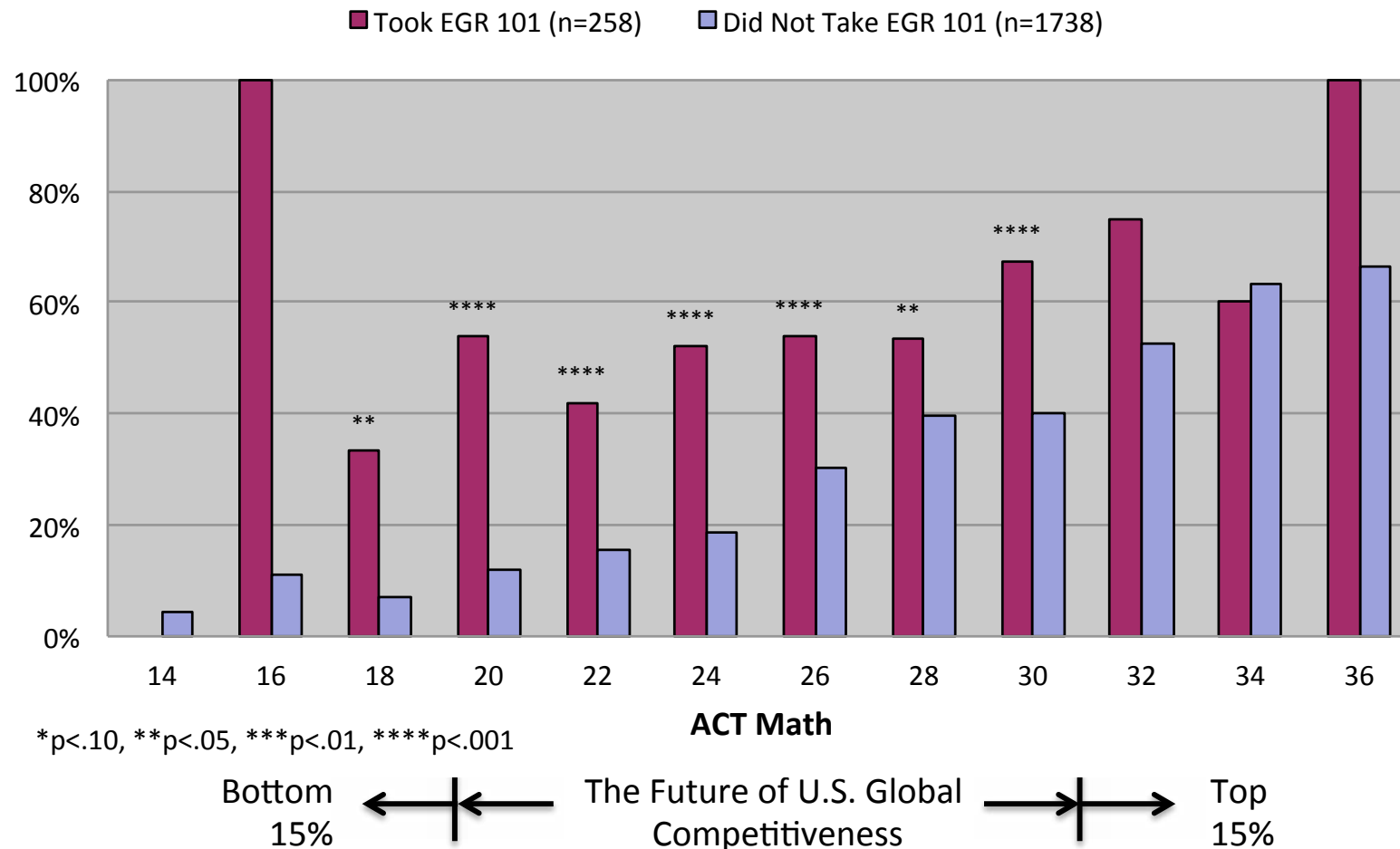


$$(\bar{x}, s_x) = (23.9, 4.70)$$

- ❑ On average, students who took EGR 101 were in fact somewhat more prepared, since many initially underprepared students dropped out before ever getting there.
- ❑ Still, a number of initially underprepared students did ultimately take the course.

And This Was the Result...

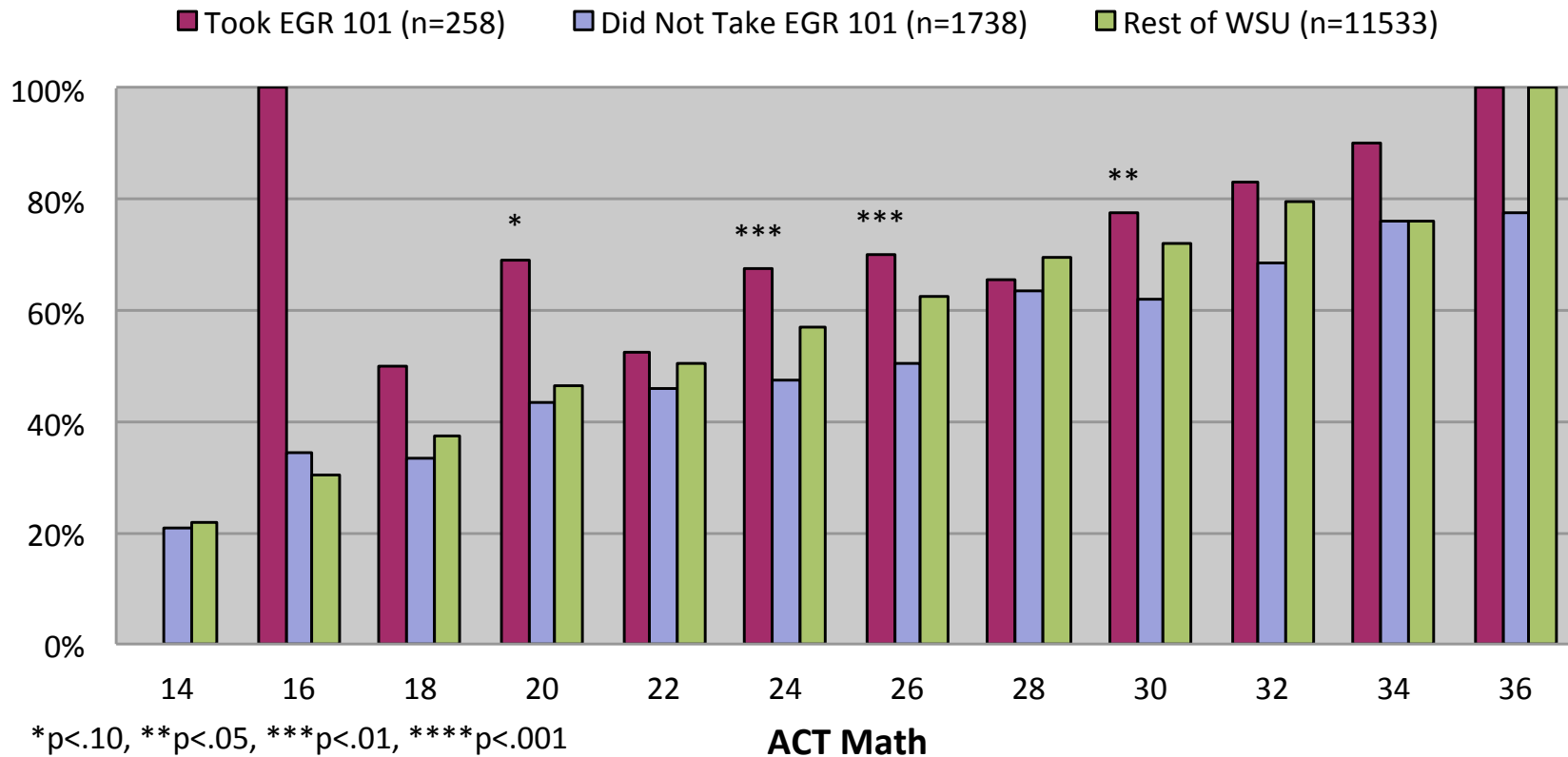
Impact of EGR 101 on CECS Graduation Rates All DFHS Students Entering Fall 2000-Fall 2006 Earning CECS Degree



EGR 101 has successfully mitigated the impact of incoming math preparation over the entire range of incoming ACT math scores

And Even for the *Switchers*...

Impact of EGR 101 on WSU Graduation Rates All DFHS Students Entering Fall 2000-Fall 2006 Earning Any WSU Degree



- ❑ Of students who took EGR 101, 70% earned Wright State degrees, compared to 51% of those who did not. Rest of WSU: 46%

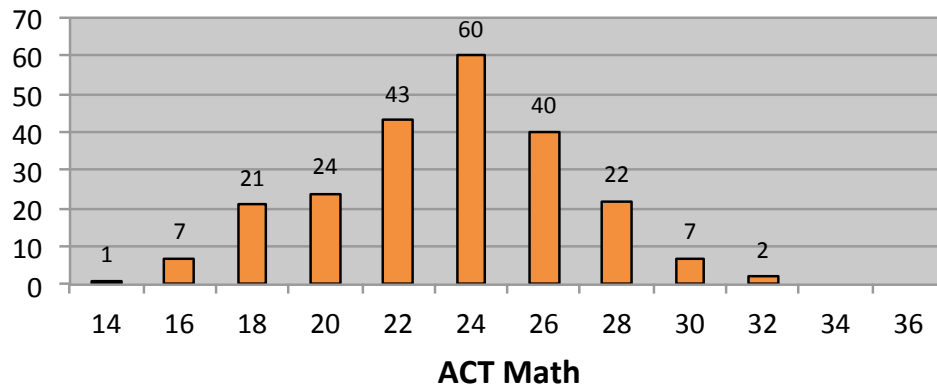
So What About the *Rest* of the Students?



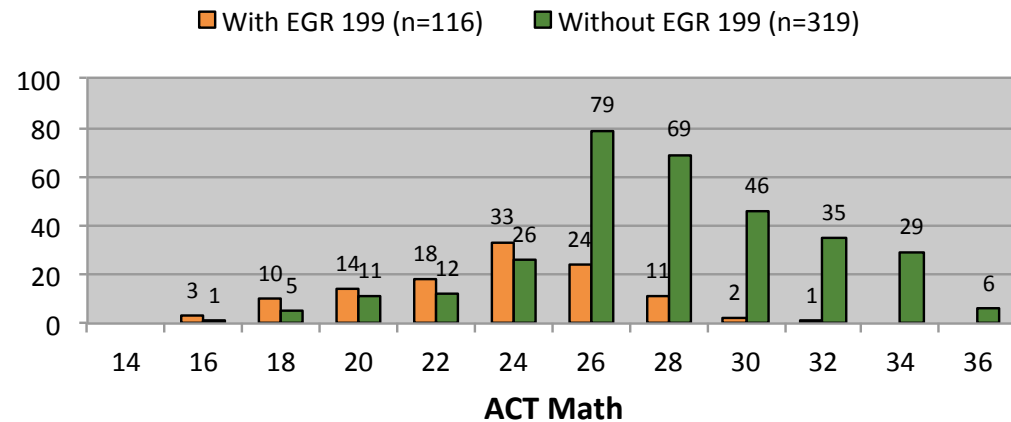
- ❑ Despite the success of EGR 101, our curriculum was still not immediately accessible to our *average* incoming student, who has a math placement level (MPL) of around 4.3 (EGR 101 requires MPL 5 or ACT Math 25 plus Trig)
- ❑ As a result, EGR 199 Preparatory Mathematics for Engineering and Computer Science was introduced as a precursor to EGR 101, with an initial enrollment of 111 MPL 3 and 4 students in Fall, 2007
 - EGR 199 covers only pre-calculus topics, from algebra through trigonometry, with all topics motivated by their actual application in core engineering and computer science courses
 - EGR 199 serves as an alternative prerequisite to EGR 101, and provides an opportunity for incoming students (including CS/CEG majors) to raise their MPL scores and avoid as many as three remedial math courses before advancing in their chosen degree programs

Longitudinal Impact of EGR 199 on Enrollment in EGR 101

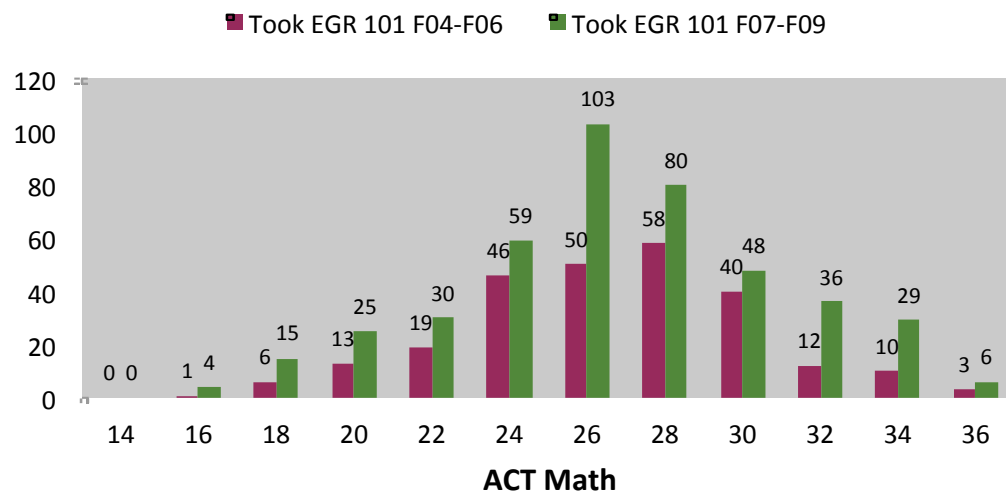
Took EGR 199 F07-F09 (n=227)



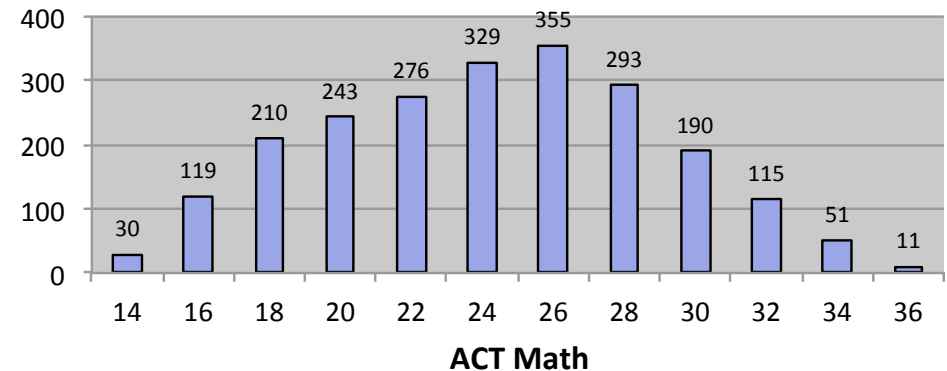
Took EGR 101 F07-F09 (n=435)



Took EGR 101 F04-F06 (n=258) and F07-F09 (n=435)



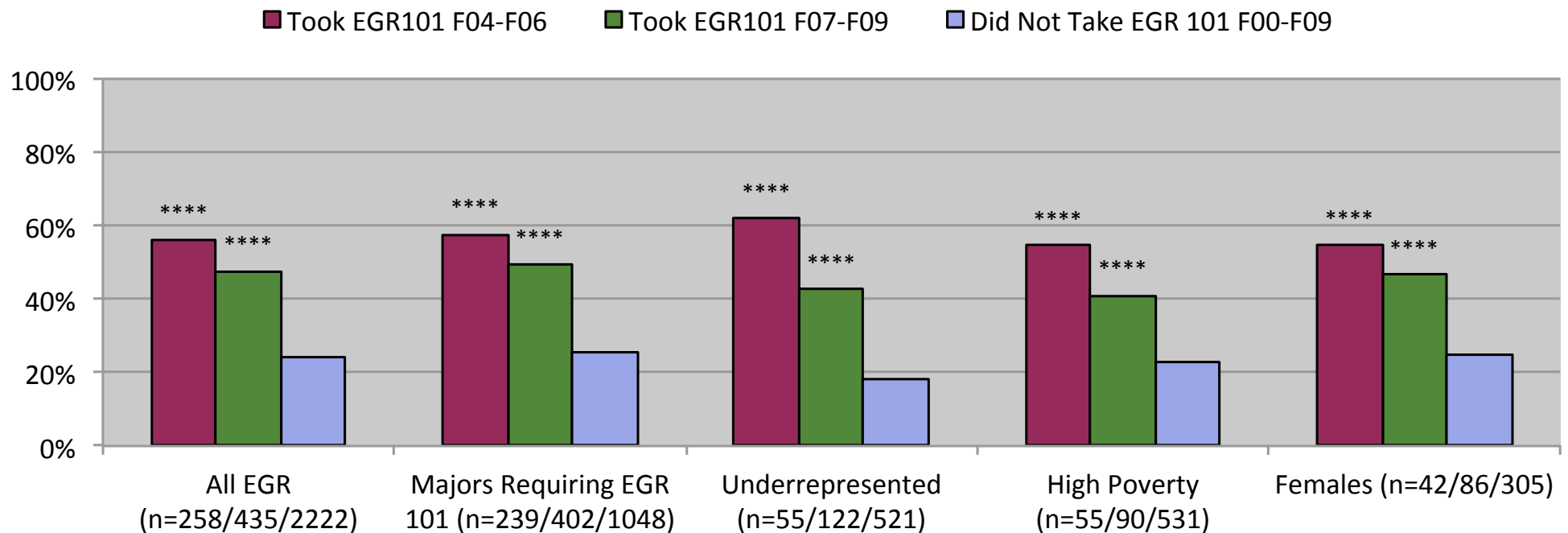
Did Not Take EGR 101 F00-F09 (n=2222)



Impact of EGR 101 on Graduation Rates: Pre and Post EGR 199



Impact of EGR 101 on CECS Graduation Rates All DFHS Students Entering Fall 2000-Fall 2009 Earning CECS Degree



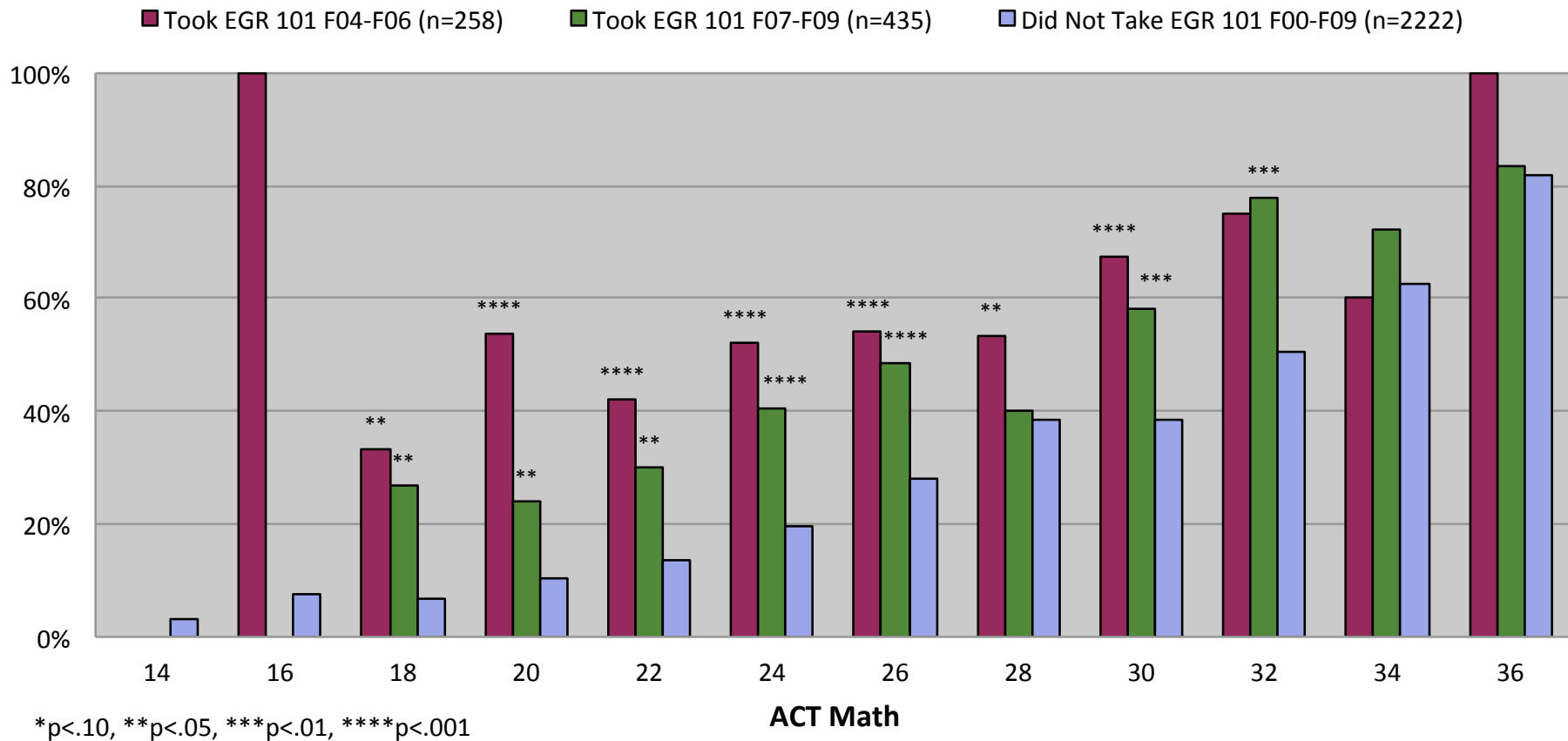
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Demographic Group

Graduation Rates Sorted by ACT Math: Pre and Post EGR 199



Impact of EGR 101 on CECS Graduation Rates All DFHS Students Entering Fall 2000-Fall 2009 Earning CECS Degree



Bottom
15% ←

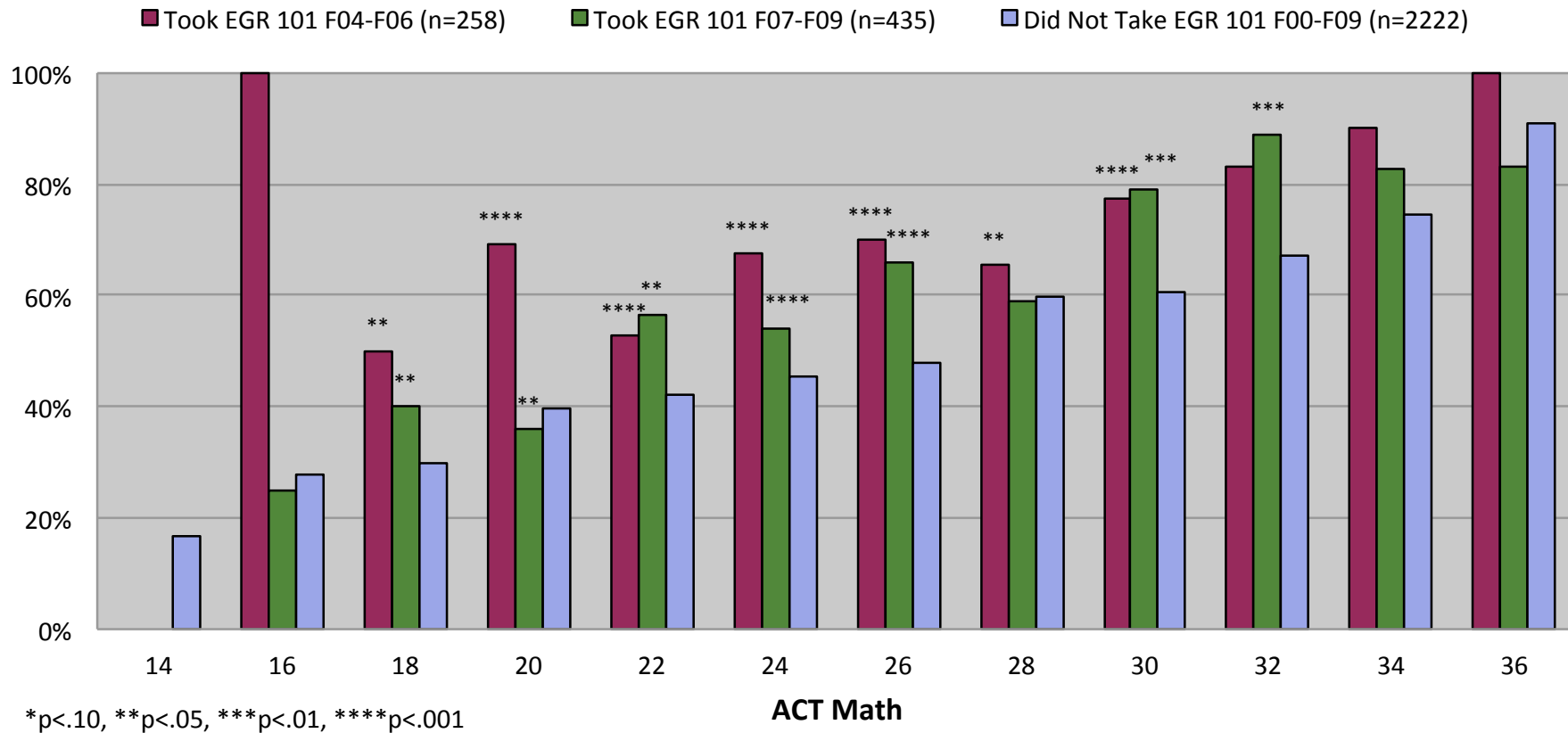
The Future of U.S. Global
Competitiveness

→ Top
15%

Impact of Increasing Enrollments in EGR 101 on WSU Graduations



Impact of EGR 101 on WSU Graduation Rates All DFHS Students Entering Fall 2000-Fall 2009 Earning Any WSU Degree

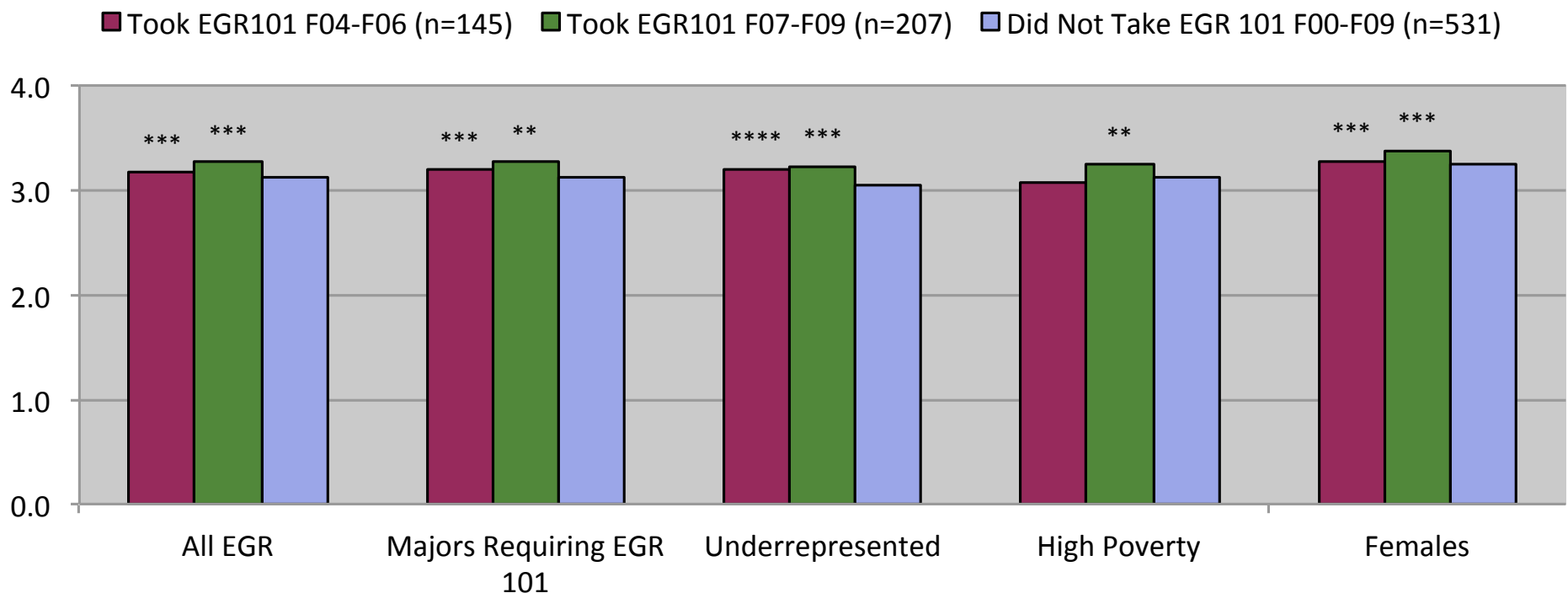


While the ultimate graduation rates of students who took EGR 101 dropped from 69.8% to 64.1%, the enrollment in EGR 101 increased from 258 to 435 (or 69%).

Net result: An additional 99 WSU degrees awarded

What About the Caliber of our Engineering Graduates?

Impact of EGR 101 on GPA of CECS Graduates All DFHS Students Entering Fall 2000-Fall 2009 Earning CECS Degree



*p<.10, **p<.05, ***p<.01, ****p<.001

Demographic Group

Net result of the Wright State Model:

Larger number, higher caliber, more diverse engineers.

“A National Model for Engineering Mathematics Education”

Grant Number DUE-0817332, 08/01/08-07/31/16

Total Funding: \$2,400,000 – Including 2013 HBCU Supplement

18 Collaborating Institutions:

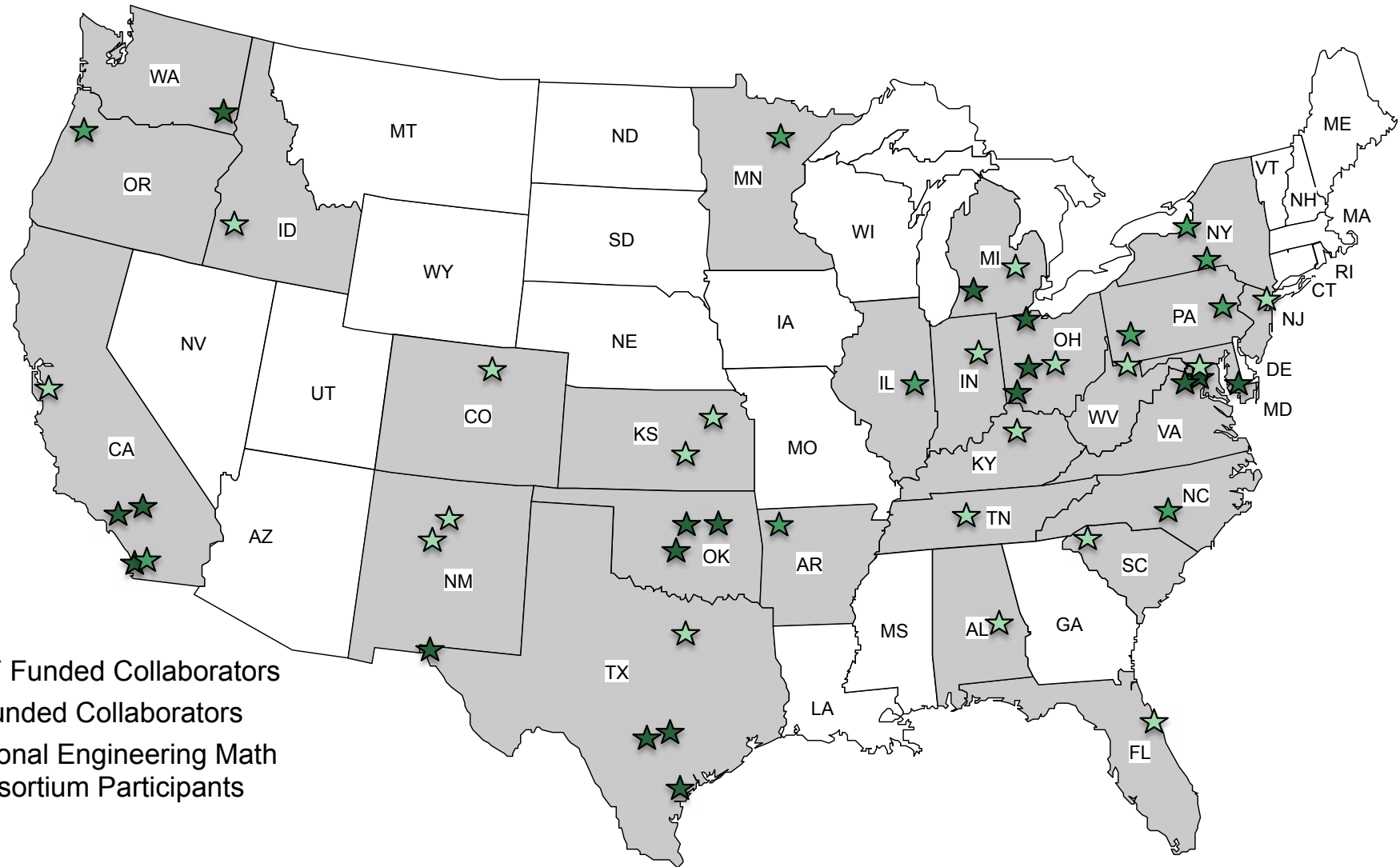
California Baptist University, California State University-Long Beach, Chantilly Academy (Fairfax County Public Schools, VA), **Howard University**, **Morgan State University**, Oklahoma Christian University, Oklahoma State University, San Antonio College, Texas A&M University - Kingsville, University of Cincinnati, **University of Maryland Eastern Shore**, University of San Diego, University of Texas at El Paso, University of Texas at San Antonio, University of Toledo, University of Tulsa, Washington State University, Western Michigan University

External Evaluator:

University of Maryland - College Park

Potential for National Impact

10,000 More Engineers... Times Seven



- ★ NSF Funded Collaborators
- ★ Unfunded Collaborators
- ★ National Engineering Math Consortium Participants

Pre-College Implementations of EGR 101 Materials



- ❑ ***Dayton Regional Summer STEM Academy:*** Three week summer program for rising juniors and seniors
- ❑ ***Dual-Enrollment implementations in Dayton and Columbus area schools:*** Bellbrook High School, the Dayton Regional STEM School, Carroll High School, Miamisburg High School, New Albany High school. Multiple additional school districts under consideration.
- ❑ ***Chantilly High School Academy (Fairfax County, VA):*** 36 week high school engineering mathematics curriculum
- ❑ ***Multiple dual-credit offerings at DC area high schools*** (Friendship Collegiate Academy, Oxon Hill High School) with University of Maryland credit
- ❑ ***Additional school districts under consideration across the country***

Current Dual-Credit Implementation at WSU

(Now Under Semester Course Number EGR 1010)



- ☐ Poised for large-scale adoption through *Ohio's College Credit Plus program*
- ☐ *Flexible modes of delivery*, including asynchronous on-line lecture and laboratory modules to facilitate co-instruction with high school teachers
- ☐ Counts toward WSU *general education and integrated writing (IW)* requirements, even for non-engineering majors
- ☐ Counts toward *Engineering University Transfer (EUT)* program at Sinclair Community College (for students articulating to WSU)
- ☐ Can be aligned with *PLTW capstone requirements*

Recommended Math Pathways for Engineering Students



1. Students who are calculus ready (or above) should enroll in EGR 101 in Fall and continue with calculus in Spring
2. Students placing in pre-calculus (one course behind Calc I) should be enrolled in both pre-calculus and EGR 101 in Fall
3. Students placing more than one course behind Calc I should be enrolled in a discipline-specific intervention in Fall designed to increase math placement levels. These students should have the *opportunity* to be calculus ready within a single semester.

Do not enroll students in an entire sequence of prerequisite math courses which do not count toward their intended degrees!

Implementation



- 1. Obtain the support of upper administration.*** Focus on business model. Tuition revenues from increased student retention and success exceed implementation costs by an order of magnitude.
- 2. Get faculty buy-in.*** Identify (and compensate) one faculty champion to shepherd the course and associated prerequisite changes through the curricular approval process.
- 3. Resource the course appropriately,*** including only top teaching faculty and undergraduate student TA support.
- 4. Work collaboratively among 2-year and 4-year colleges*** for seamless articulation across institutions.

Program Website:

- Links to All Course Materials
- YouTube Lecture Videos
- TEDx Dayton Talk
- EGR 101 Textbook

<http://www.cecs.wright.edu/engmath/>

Contact and Faculty Mentor:

Dr. Craig Baudendistel

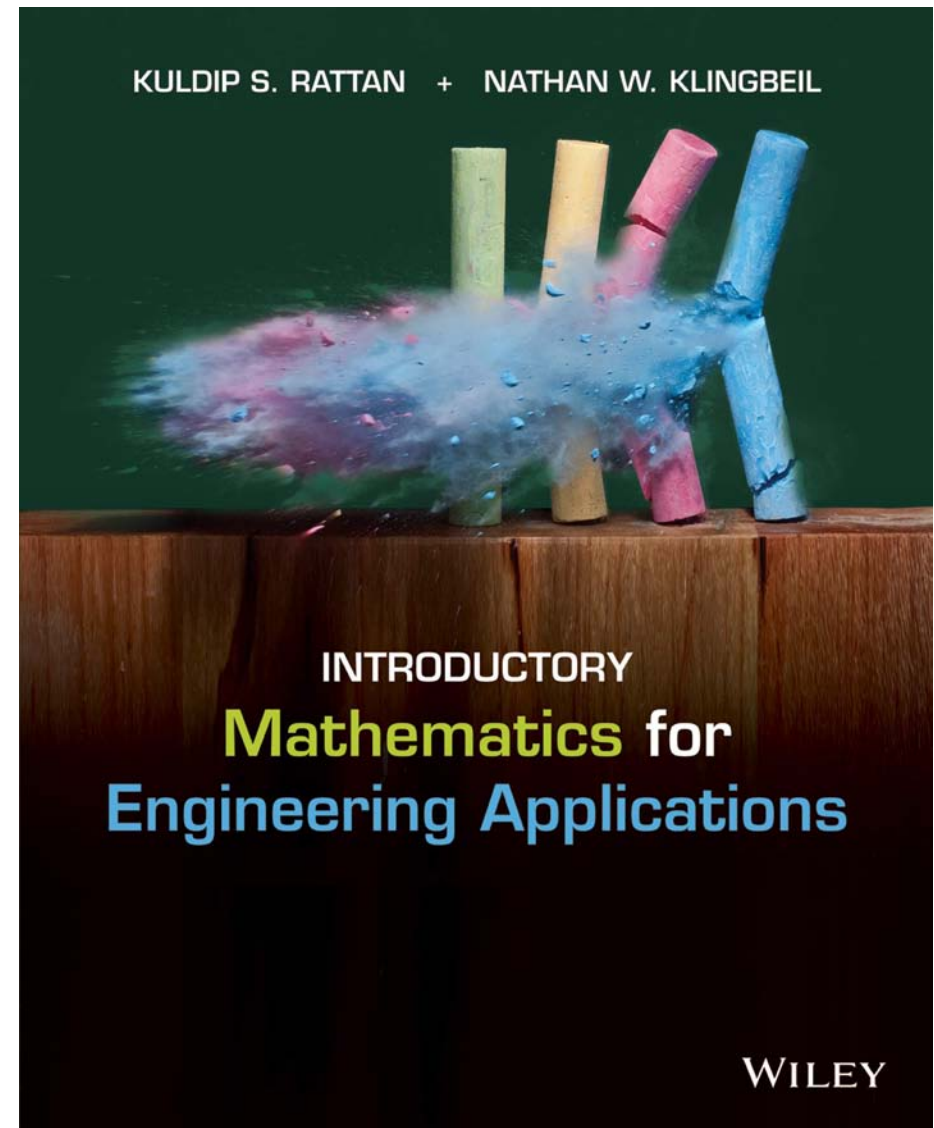
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Questions

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