WRIGHT STATE UNIVERSITY

A National Model for Engineering Mathematics Education

Longitudinal Impact at Wright State University

Support:

National Science Foundation

Grant Numbers EEC-0343214, DUE-0618571, DUE-0622466, DUE-0817332

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

Motivation and Objective

Motivation:

- Historically, only about 40% of incoming engineering students ever made it past the the traditional freshman calculus sequence at Wright State University

- This problem is not unique to WSU; indeed, math-related attrition plagues engineering programs across the country



Objective:

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

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The Wright State Model

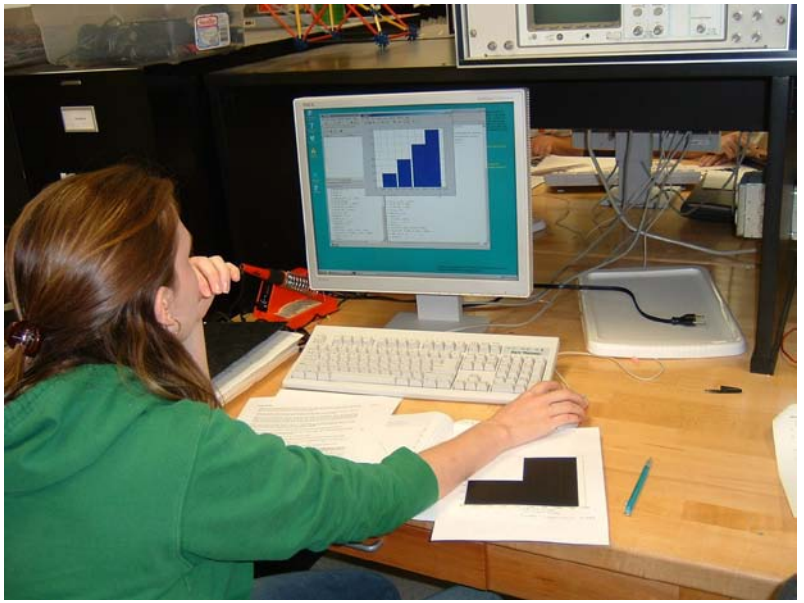
1. Develop a first-year engineering math course EGR 101, taught by *engineering* faculty, addressing only the salient math topics *actually used* in core engineering courses: physics, engineering mechanics, electric circuits, computer programming

2. Restructure the early engineering curriculum, with EGR 101 as the *only* math prerequisite for the above core courses

3. Provide a more just-in-time structuring of the required calculus sequence, in concert with College and ABET requirements

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 motivated by hands-on laboratory exercises, including a thorough integration with MATLAB

Restructured Curriculum
(Effective Fall, 2004)

- Traditional First-Year Curriculum (Mechanical Engineering):

Fall Quarter		Winter Quarter		Spring Quarter	
ENG 101	4	ENG 102	4	ME 199	3
EGR 190	4	EGR 153/CEG 220	4	PHY 240	5
CHM 121	5	GE	4	GE	4
MTH 229 Calc I*	5	MTH 230 Calc II*	5	MTH 231 Calc III*	5
	18		17		17

* Traditional freshman calculus sequence

- Restructured First-Year Curriculum (Mechanical Engineering):

Fall Quarter		Winter Quarter		Spring Quarter	
ENG 101	4	ENG 102	4	ME 199	3
EGR 190	4	EGR 153/CEG 220	4	PHY 240	5
CHM 121	5	MTH 229 Calc I**	5	GE	4
EGR 101*	5	ME 220	3	ME 202	4
	18		16		16

* New freshman engineering mathematics course

** First course in the revised engineering calculus sequence, with separate sections for engineers.

Revised Math Sequence

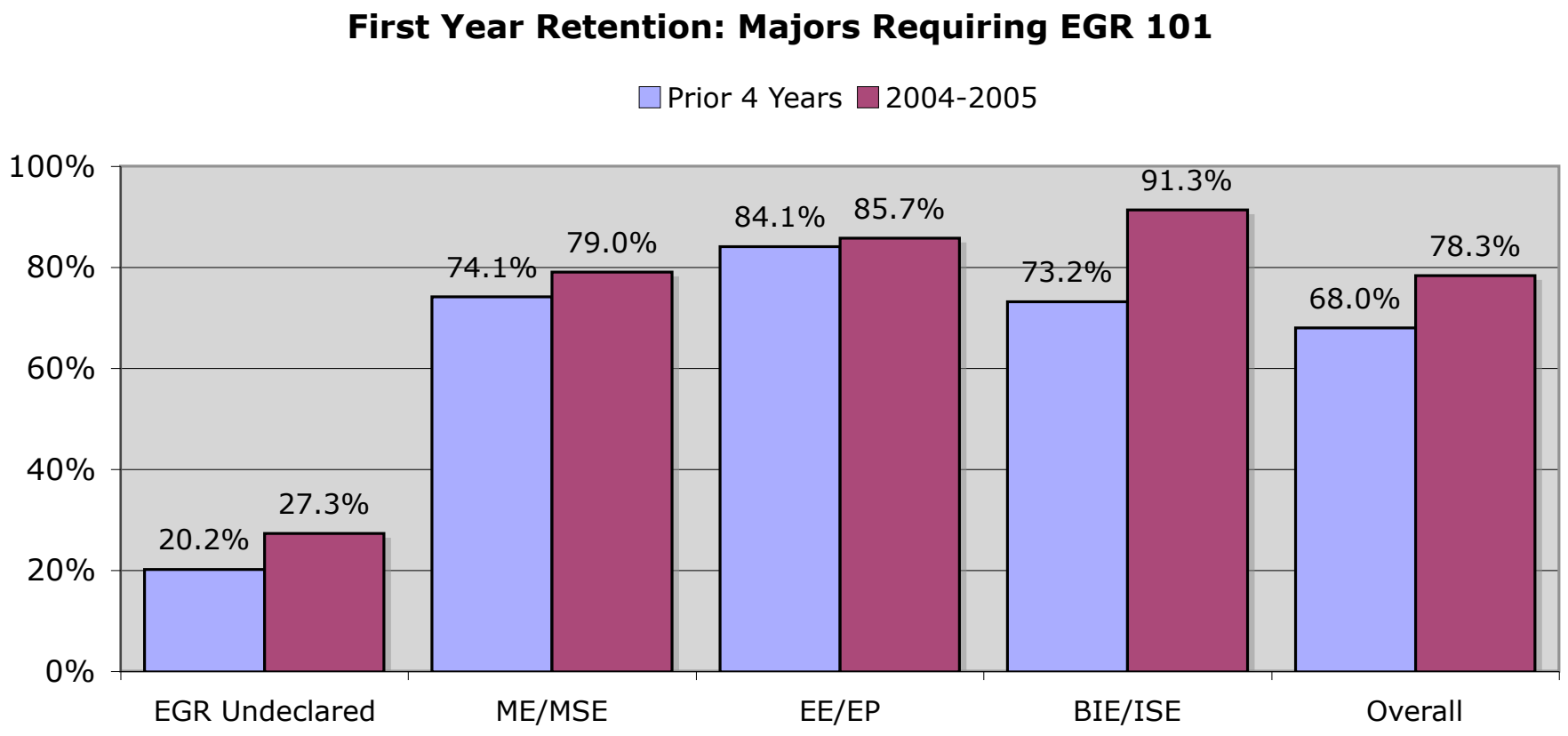
- EGR 101 (5 hours, freshman year)
- Required Calculus Sequence (5 hours each)
  - Calc I (freshman year)
  - Calc II (sophomore year)
  - Calc III (sophomore year)
  - Calc IV (junior year)
- Differential Equations with Matrix Algebra (5 hours, sophomore year)

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."

Initial Impact: First-Year Retention

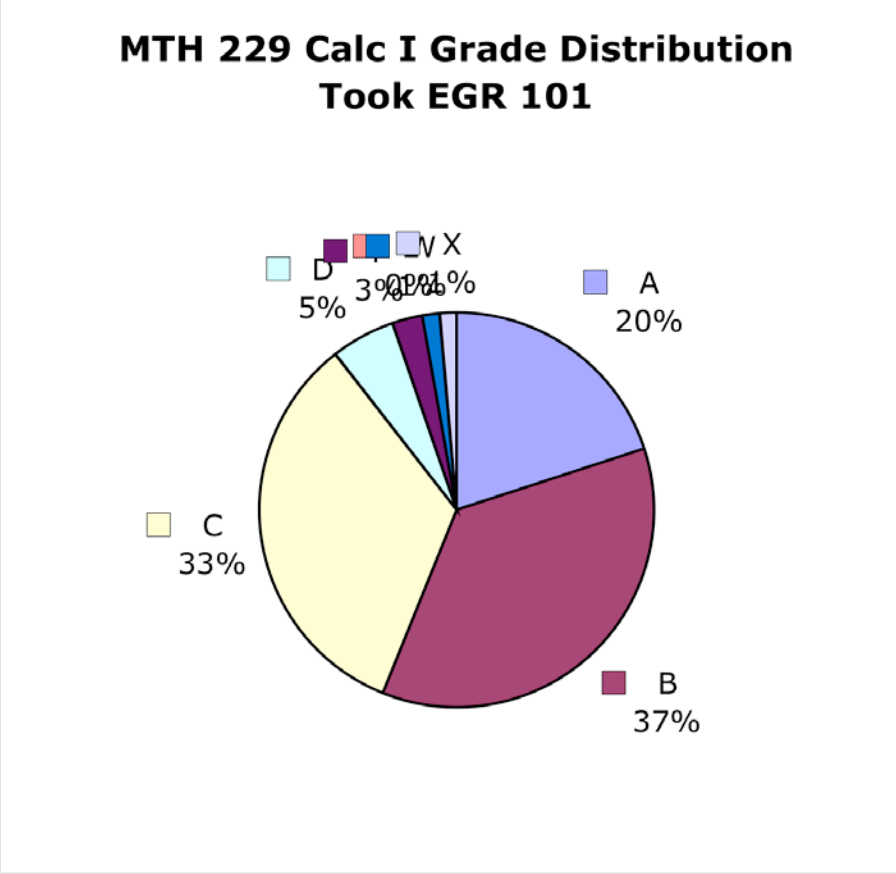
- Every department requiring EGR 101 saw an increase in first-year (Fall-to-Fall) retention in 2004-2005:

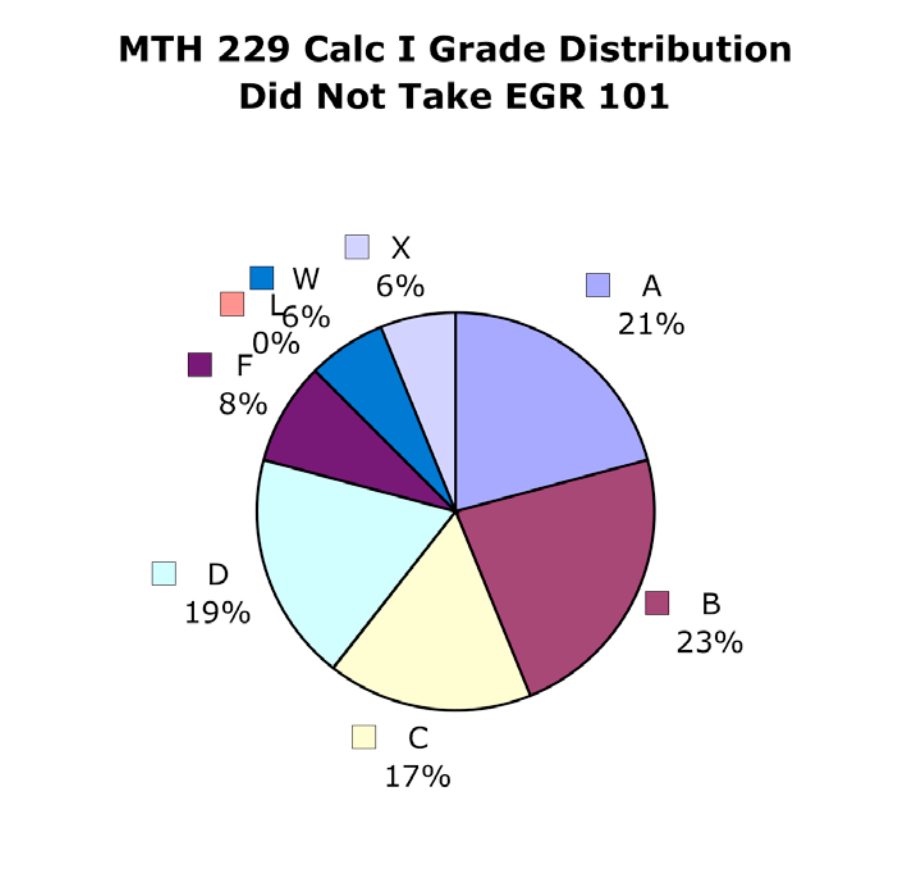


- Overall, first-year retention for majors requiring EGR 101 increased from 68.0% to 78.3%

Student Performance in Calculus

(Fall 2004 Cohort)

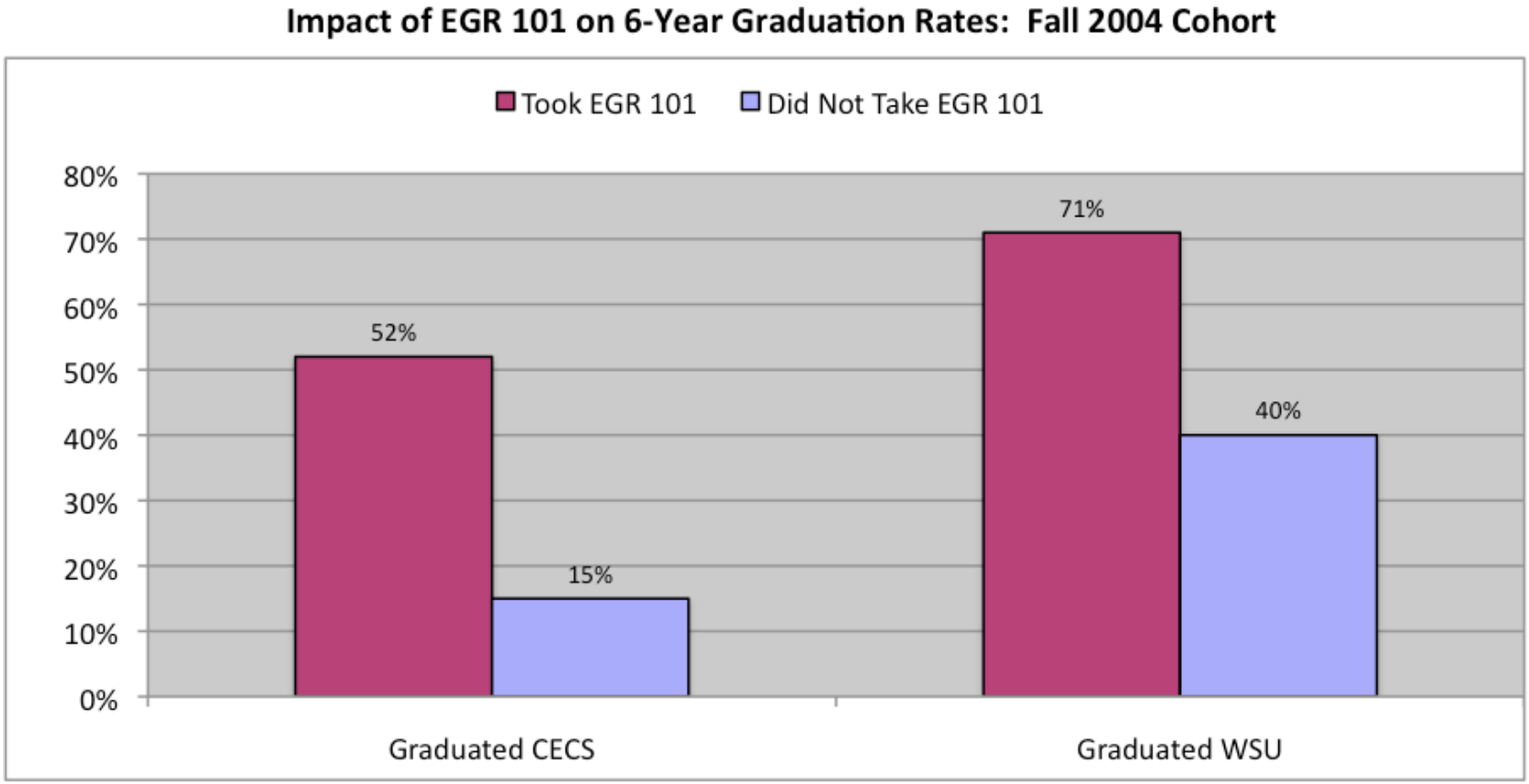




- Of the students ultimately enrolled in Calc I, 89% of those who took EGR 101 earned a "C" or better, compared to only 60% of those who did not

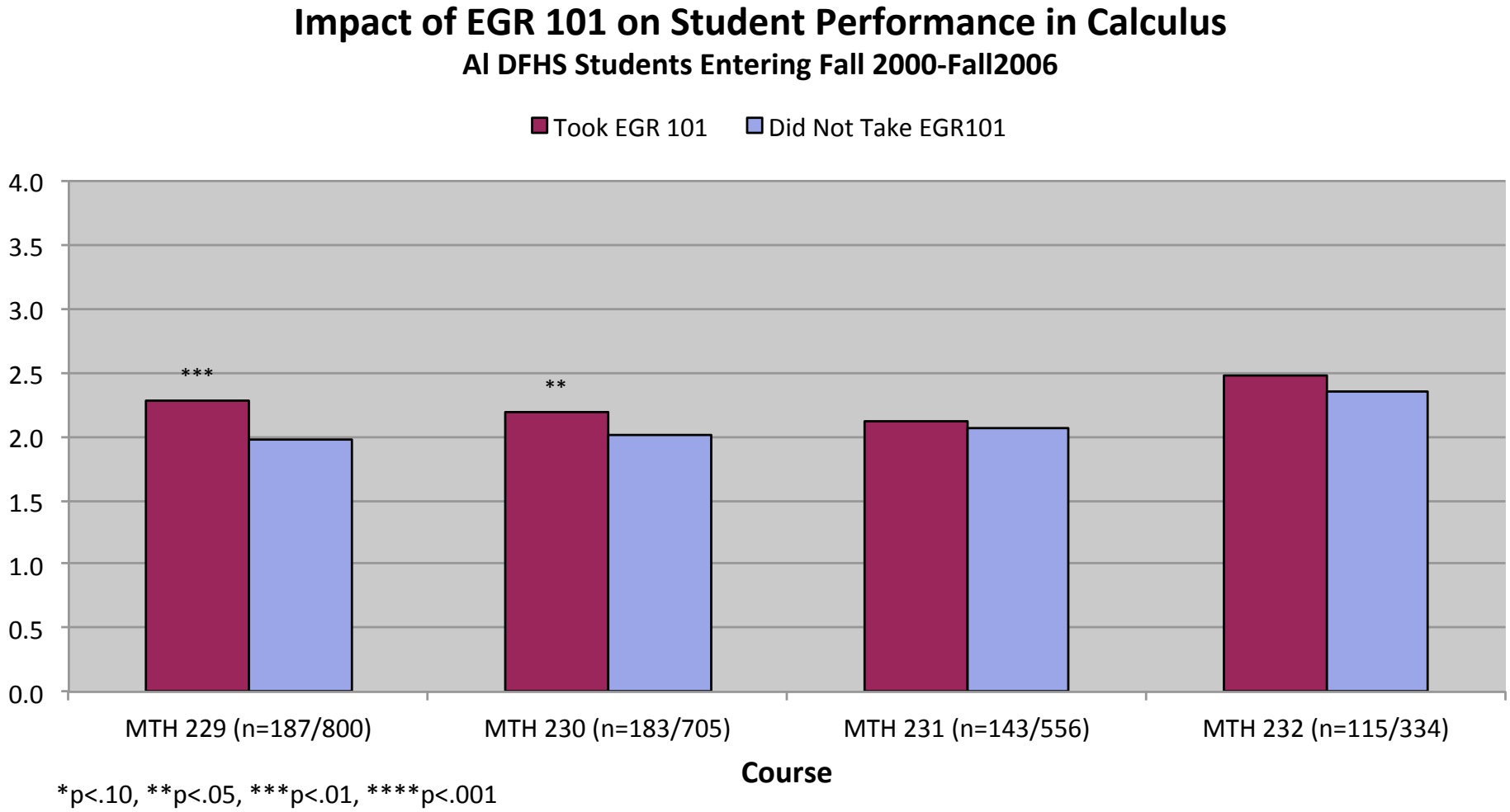
6-Year Graduation Rates

(Fall 2004 Cohort)



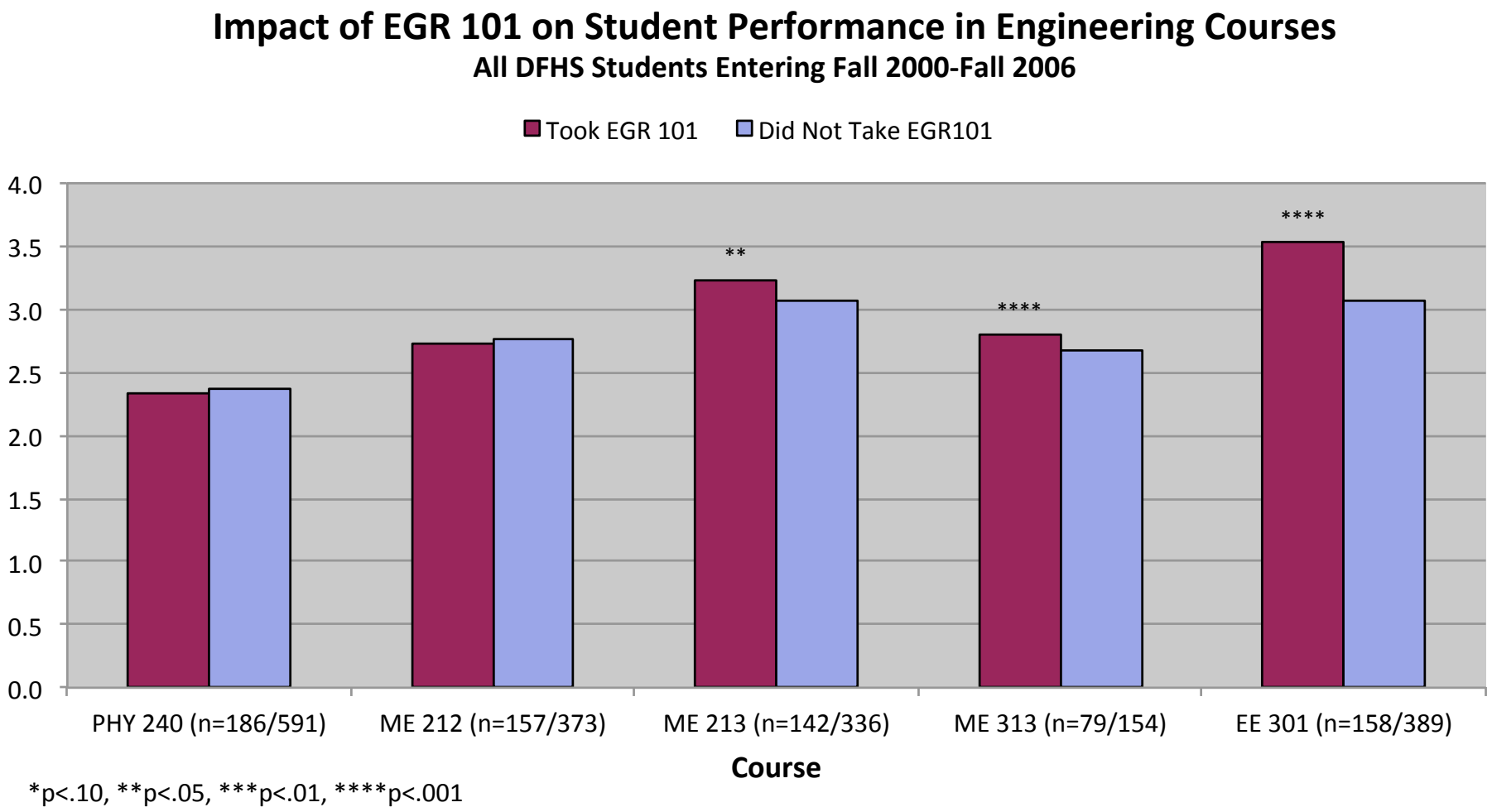
- Students who took EGR 101 had a significantly higher chance of graduating from Wright State University, whether from engineering or some other degree program

Longitudinal Study: Student Performance in Calculus



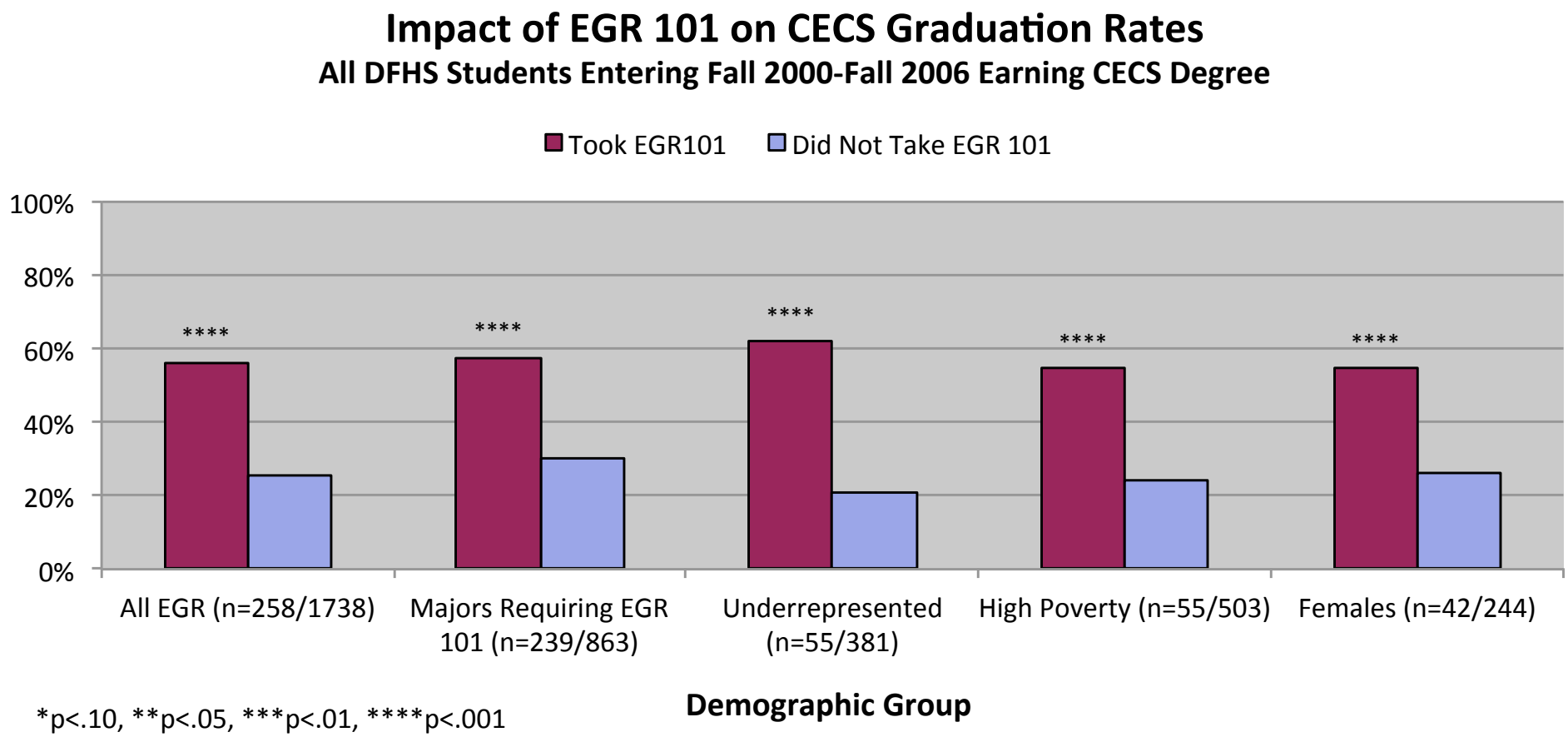
- Students who took EGR 101 had a statistically significant advantage in their first two calculus courses

Longitudinal Study: Student Performance in Engineering



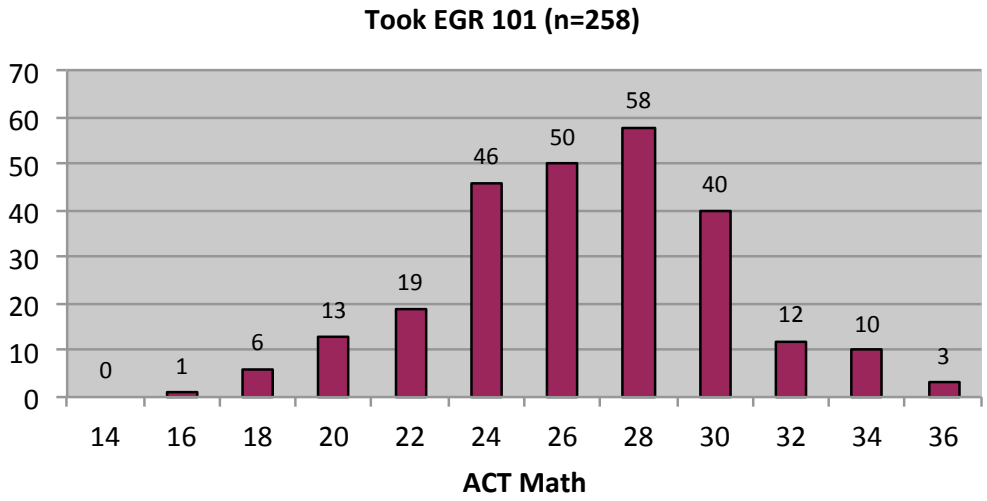
- Students who took EGR 101 had a statistically significant advantage in Dynamics, Strength of Materials and Electric Circuits. No significant difference in Physics I or Statics.

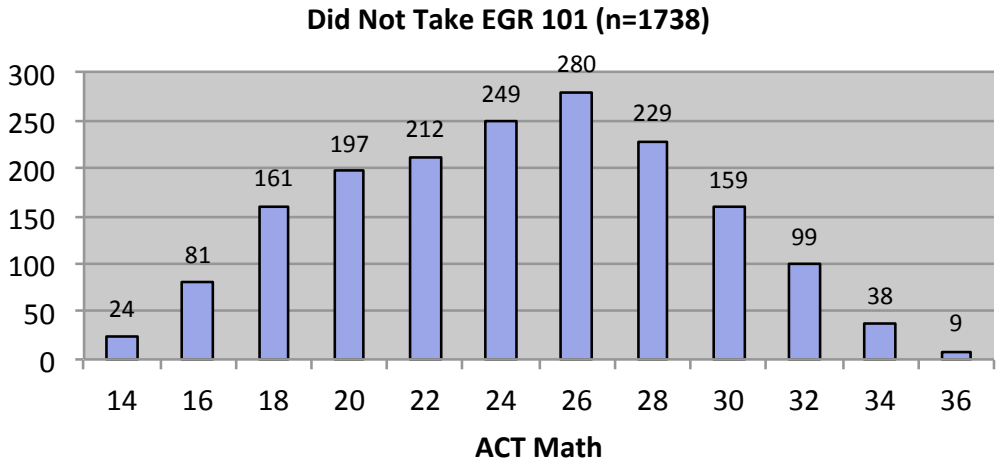
Longitudinal Study: Impact by Demographic Group



- Students who took EGR 101 had an overwhelming advantage across all demographic groups. Impact for underrepresented students was a factor of 3, the highest overall.

Longitudinal Study: Are the Populations Comparable?



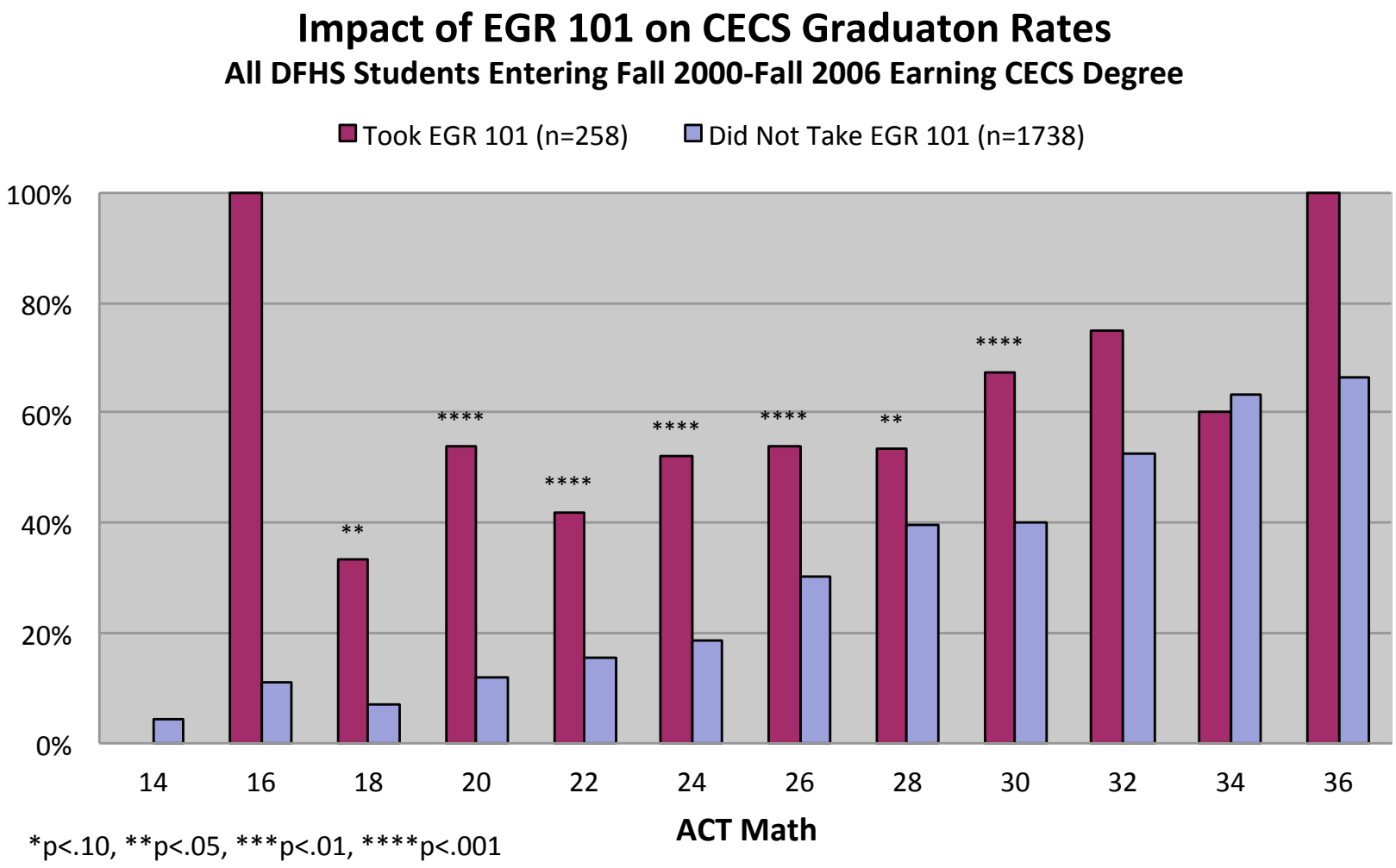


$(\bar{x},\ s_x) = (26.1,\ 3.67)$

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

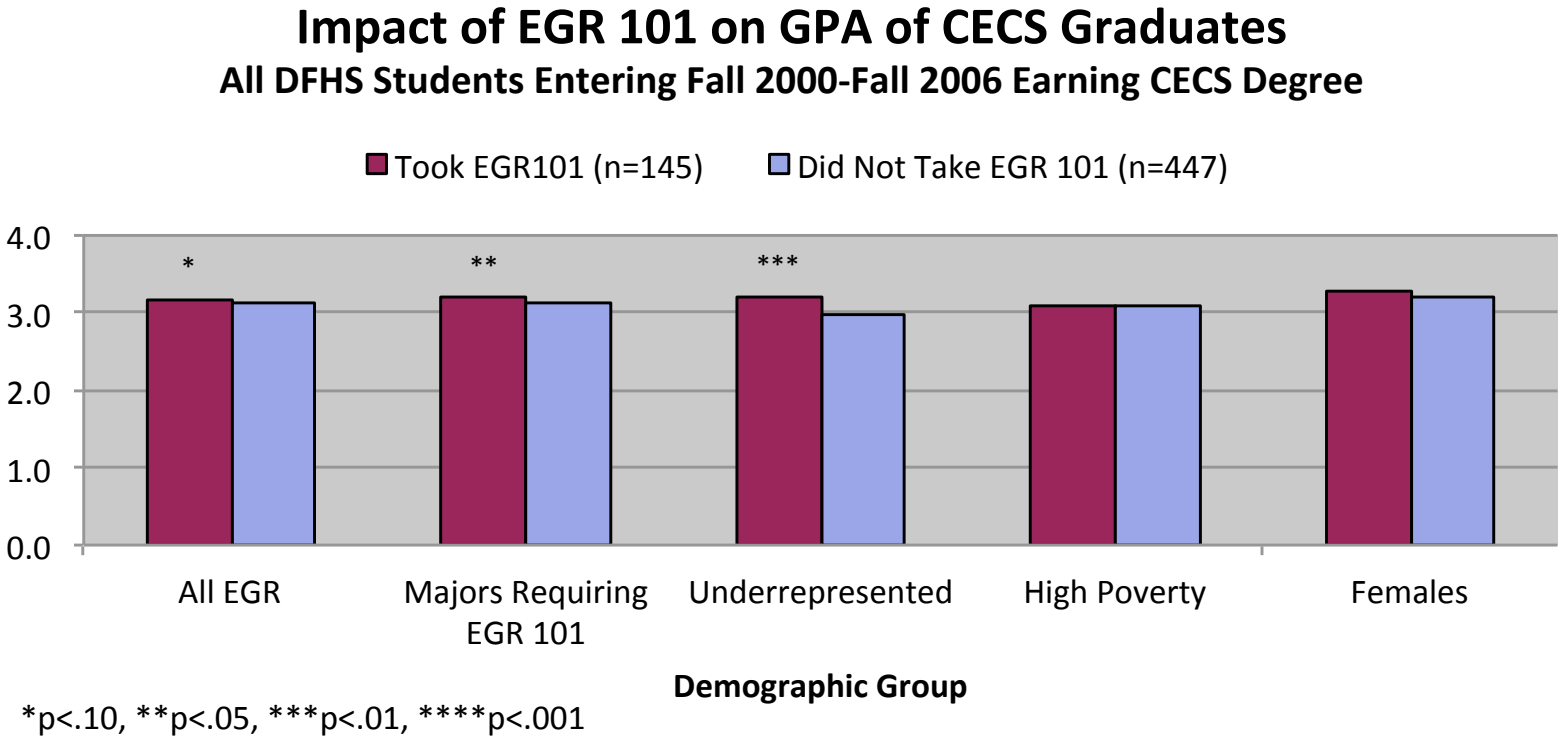
- On average, students who took EGR 101 were in fact somewhat more prepared, since many initially underprepared students dropped out before ever getting there.
- Still, a number of initially underprepared students did ultimately take the course.

And This Was the Result…



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

What About the Caliber of Our Engineering Graduates?



- Despite graduating a higher proportion of initially underprepared students, EGR 101 has increased both the number and *caliber* of our engineering graduates.
- The largest impact was on members of underrepresented groups.

So What About the *Rest* of the Students?

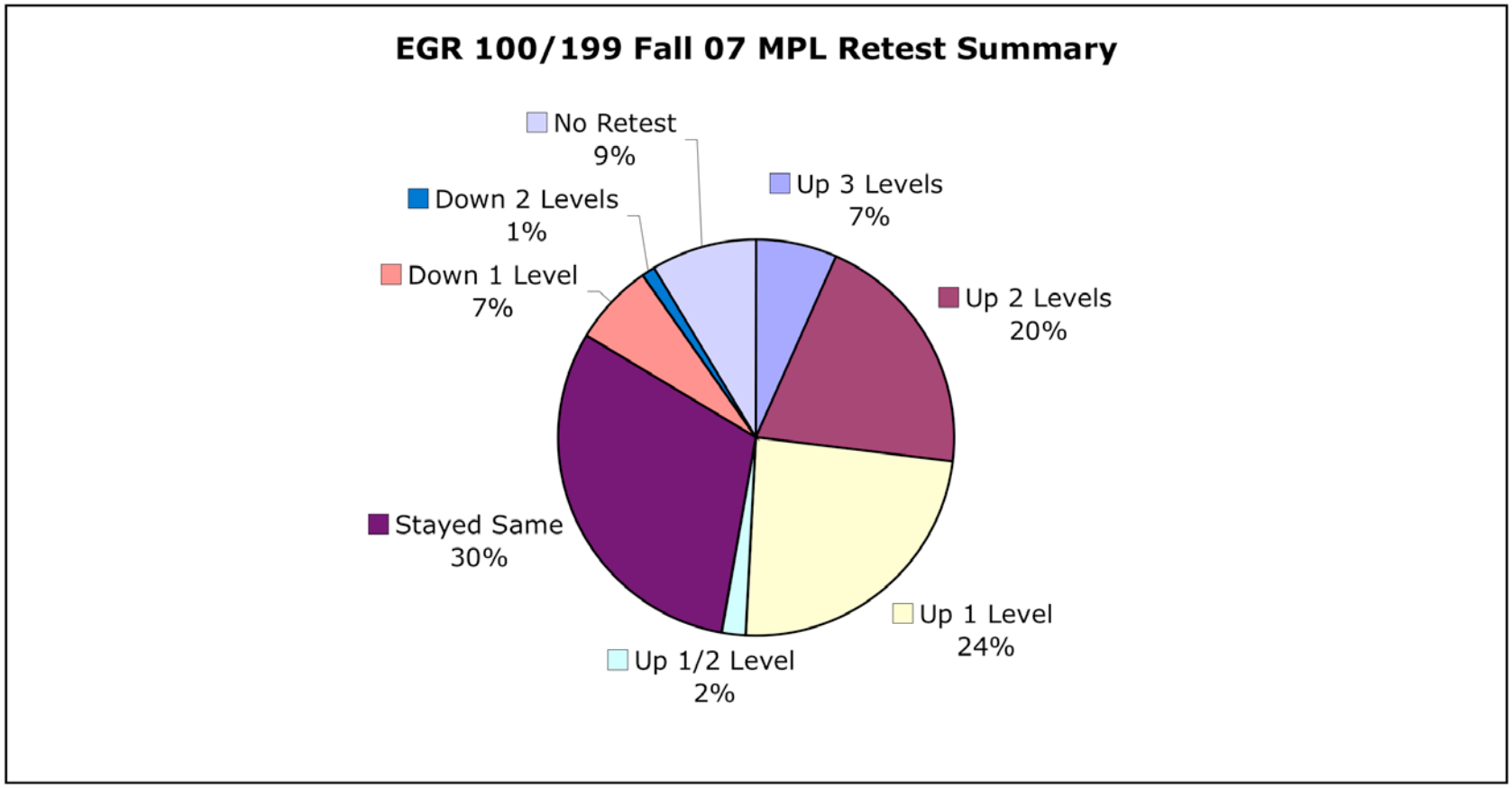
- Despite the success of EGR 101, our curriculum was still not immediately accessible to our *average* incoming student, who has an MPL of around 4.3

- As a result, EGR 100 "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 (under temporary course number EGR 199)

  - EGR 100/199 covers only pre-calculus topics, from algebra through trigonometry, with all topics motivated by their actual application in core engineering and computer science courses

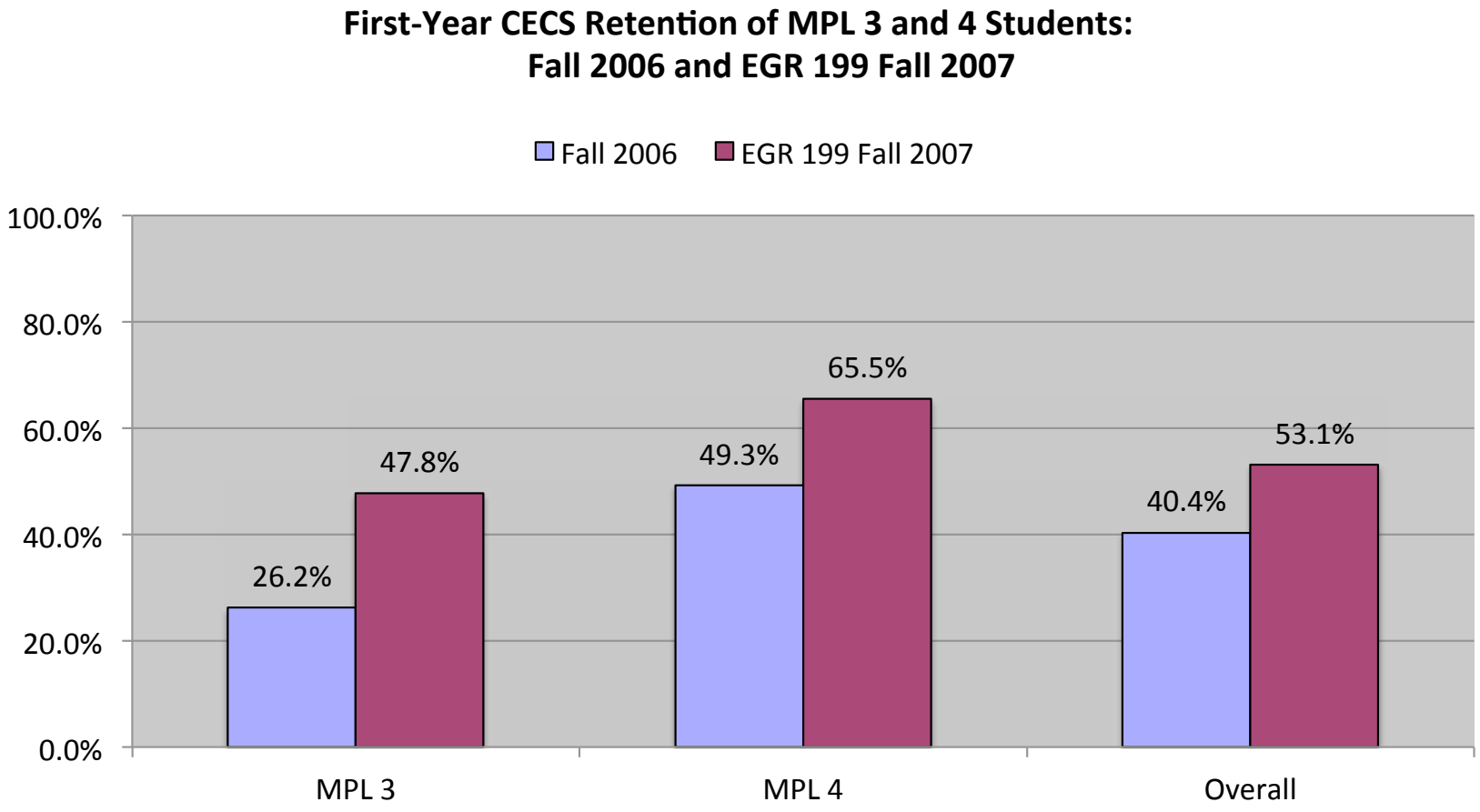
  - EGR 100/199 serves as an alternative prerequisite to EGR 101, and provides an opportunity for incoming students (including CS/CEG majors) to raise their MPL scores and avoid as many as three remedial math courses before advancing in their chosen degree programs

Results of EGR 100/199
(Initial Offering, Fall 2007)



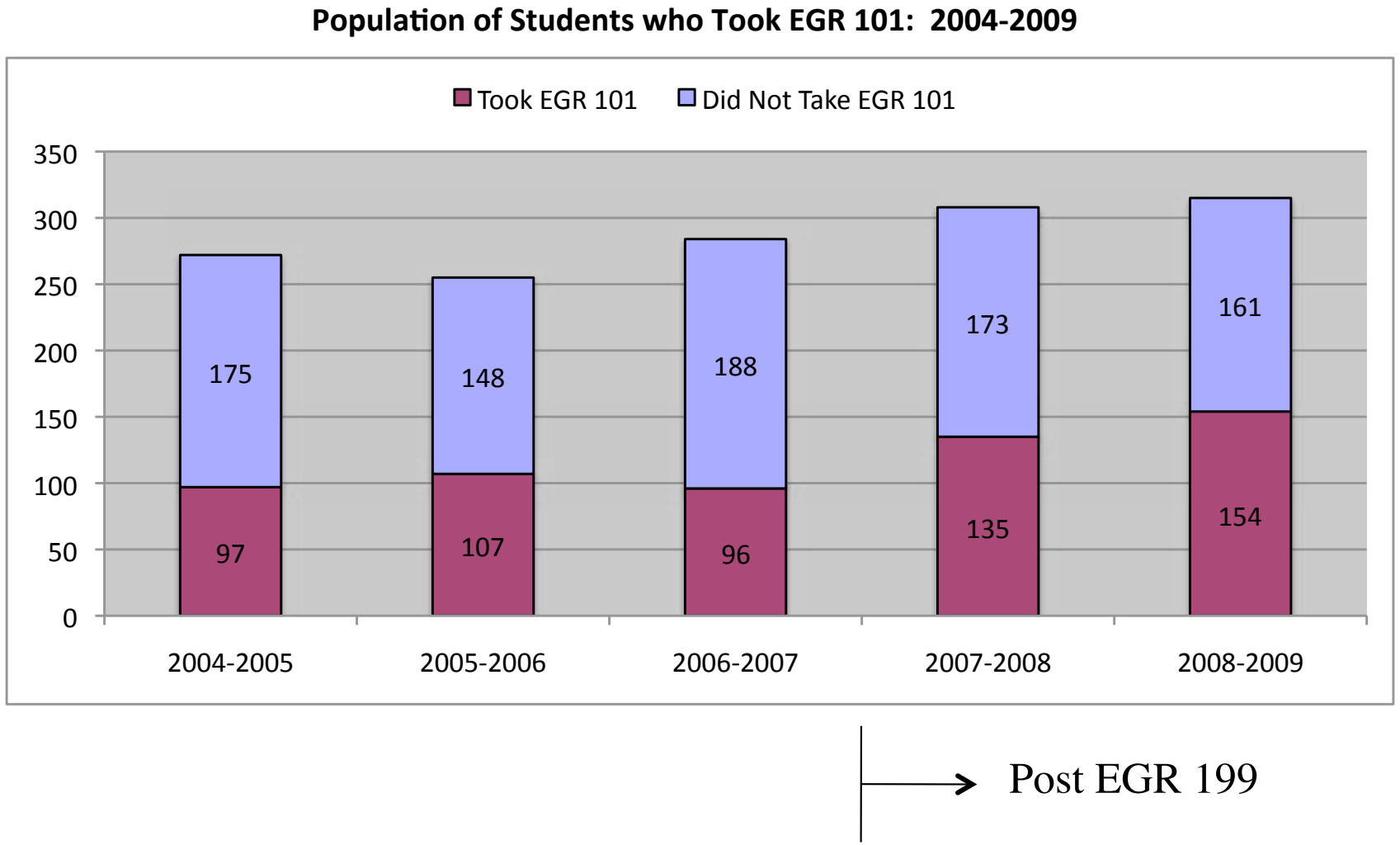
- The majority of EGR 199 students increased their MPL score by at least one level, and some by as many as three (avoiding an entire year of remedial math courses).

Results of EGR 100/199
(Initial Offering, Fall 2007)



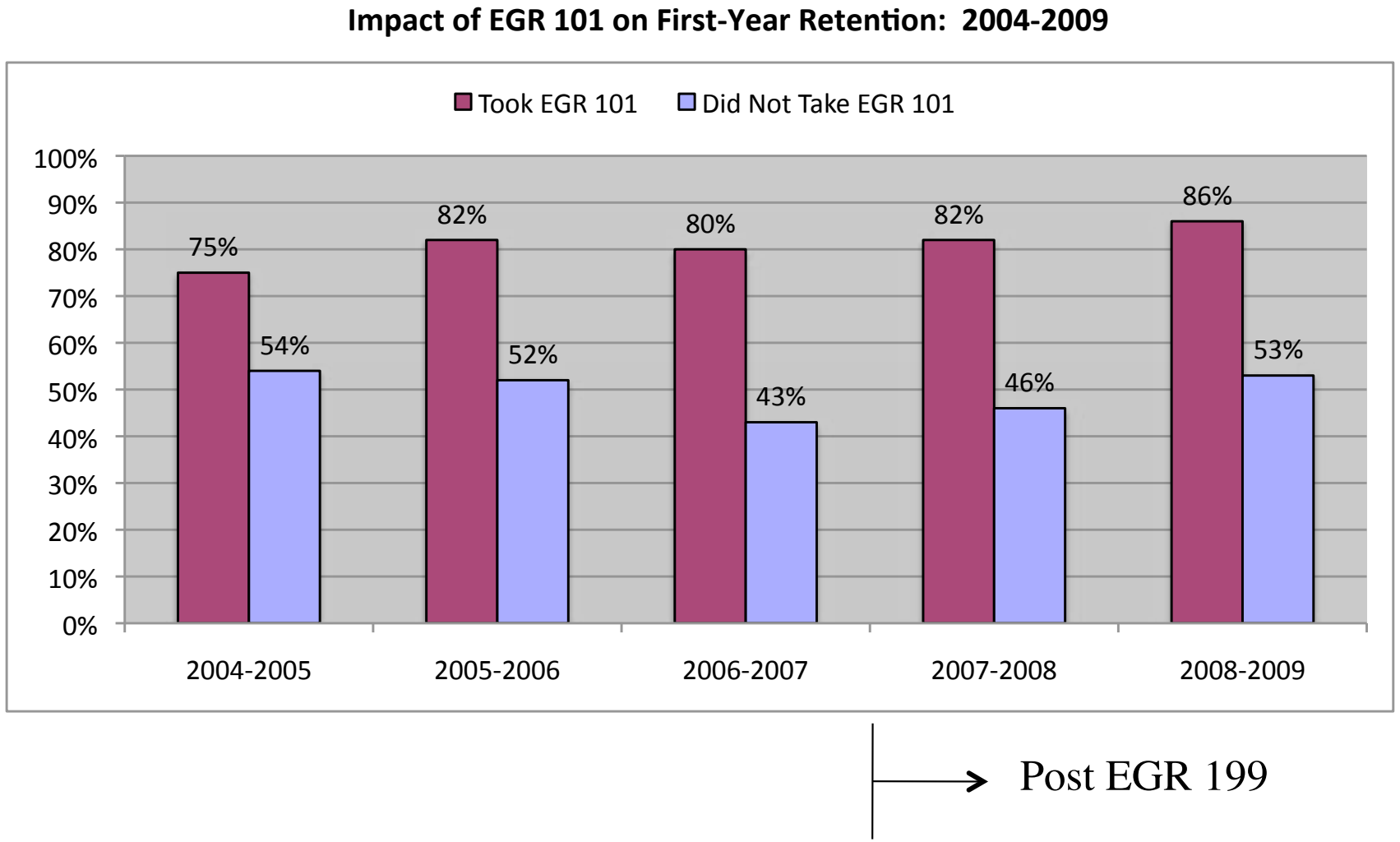
- The introduction of EGR 100/199 nearly doubled the first-year retention rate of MPL 3 students, and had a significant impact on MPL 4 students as well.

Impact of EGR 100/199 on Student Enrollment in EGR 101



- The introduction of EGR 100/199 has increased the number of first-year students enrolled in EGR 101 by roughly 50%.

Impact of EGR 101 on First-Year Retention: Post EGR 199



- Despite a significant increase in the number of initially underprepared students enrolled in the course, first-year retention for students who took EGR 101 reached an all-time high of 86%.

Pre-College Implementations of EGR 101 Materials

- Dual-Enrollment of EGR 101 at Bellbrook High School since Fall 2008. Other Dayton area schools under consideration.
- Dayton Regional Summer STEM Academy: Three week summer program for rising juniors and seniors
- 36 week high school engineering mathematics curriculum at Chantilly High School Academy (Fairfax County, VA)
- Semester offerings at DC area high schools (Friendship Collegiate Academy, Oxon Hill High School) with University of Maryland credit
- Multiple school districts under consideration across the country

NSF CCLI Phase 2 Program

"A National Model for Engineering Mathematics Education"

Grant Number DUE-0618571, 08/15/06-07/31/10.

Total Funding: $500,000

PI: N. Klingbeil

Co-PI's: K. Rattan, D. Reynolds, M. Raymer, R. Mercer

1. Multiyear assessment at WSU (student retention, motivation and success, including effect on *student learning* in subsequent math and engineering courses)

2. Pilot adoption and assessment at collaborating institutions (University of Cincinnati, University of Toledo)

3. Widespread dissemination of results: Development of an EGR 101 textbook; publication and presentation in STEM venues; workshops for faculty from across the country (build team for Phase 3)

NSF STEP Type 1 Program

"Gateway into First-Year STEM Curricula: A Community College/University Collaboration Promoting Retention and Articulation"

Grant Number DUE-0622466, 10/01/06-09/30/12.
Total Funding: $1,997,620

PI: N. Klingbeil (Replacing M. Wheatly)
Co-PI's: K. Koenig, G. Sehi, R. Jones

1. Adoption of EGR 101 and associated engineering math reforms at Sinclair Community College (SCC)
2. Development of companion SM 101/ASE 101 "Scientific Thought and Method," offered to all first-year science majors at WSU and SCC
3. Training of faculty, graduate students and senior undergraduates, who will participate in the development and implementation of the unified first-year STEM experience at WSU and SCC
4. Expected Outcomes: 10% increase in first-year STEM retention at WSU; 10% increase in articulation of STEM majors from SCC to WSU; 50 additional WSU STEM graduates per year by close of project

NSF CCLI Phase 3 Program

"A National Model for Engineering Mathematics Education"

Grant Number DUE-0817332, 08/01/08-07/31/13

Total Funding: $2,000,000

15 Collaborating Institutions:

California Baptist University, California State University-Long Beach, Chantilly Academy (Fairfax County Public Schools, VA), Oklahoma Christian University, Oklahoma State University, San Antonio College, Texas A&M University - Kingsville, University of Cincinnati, 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:

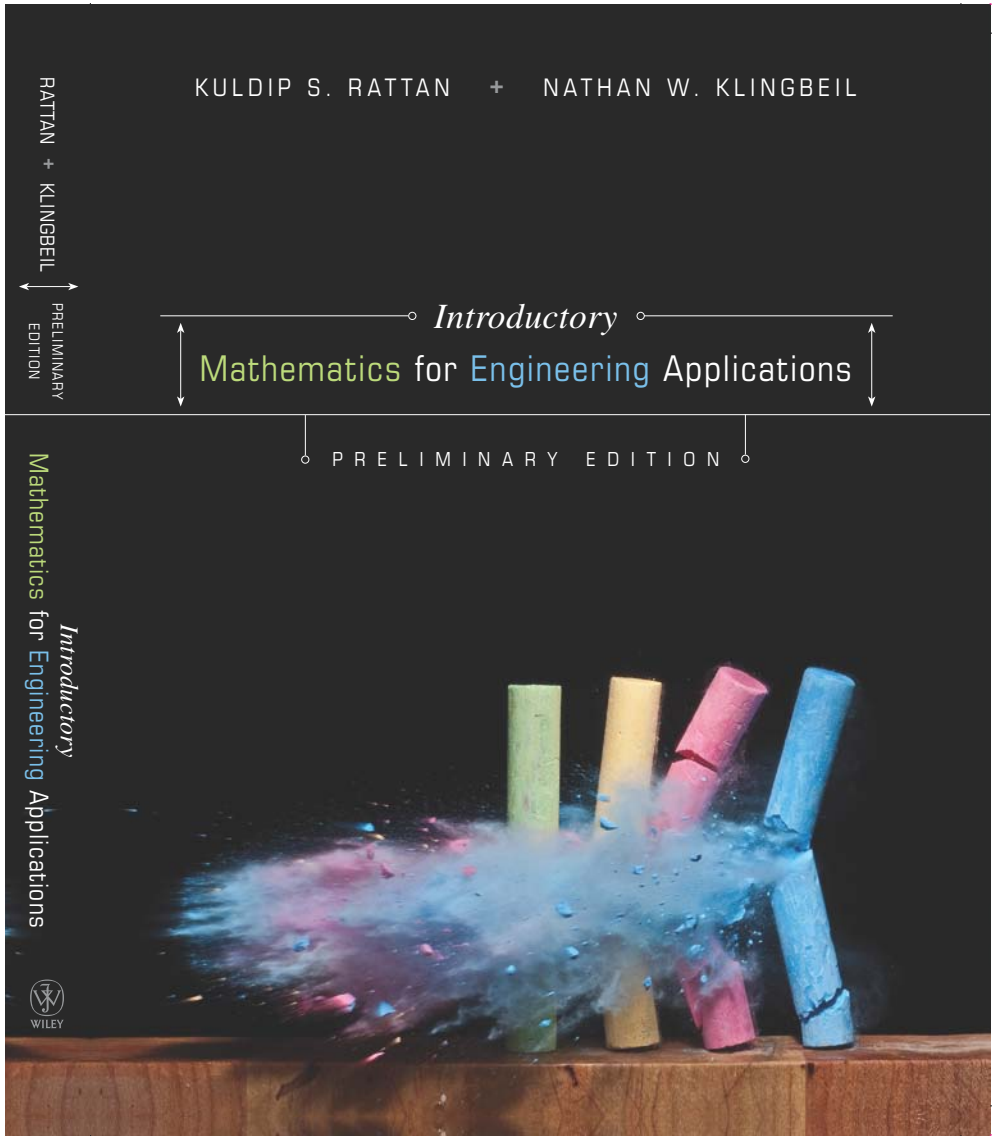
University of Maryland - College Park

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Summary

- We propose an application-driven, just-in-time approach to engineering mathematics education, with the goal of increasing student retention, motivation and success in engineering
- The approach is designed to be readily adopted by any institution employing a traditional engineering curriculum
- Student performance, perception and retention has surpassed our expectations, and verified the feasibility of the approach
- We believe the approach has the potential for an extremely broad impact, including significant increases in retention and graduation rates at universities across the country

Questions
(And Shameless Plug)



http://www.wiley.com/college/rattan