Geographical Inequities in Accessing Engineering and Computer Science: A State-wide Analysis of Undergraduate Enrollments Across High Schools

Dr. David B Knight, Virginia Tech

David B. Knight is an Associate Professor and Assistant Department Head of Graduate Programs in the Department of Engineering Education at Virginia Tech. He is also Director of Research of the Academy for Global Engineering at Virginia Tech, and is affiliate faculty with the Higher Education Program. His research tends to be at the macro-scale, focused on a systems-level perspective of how engineering education can become more effective, efficient, and inclusive, tends to be data-driven by leveraging large-scale institutional, state, or national data sets, and considers the intersection between policy and organizational contexts. He has B.S., M.S., and M.U.E.P. degrees from the University of Virginia and a Ph.D. in Higher Education from Pennsylvania State University.

Dr. Jacob R Grohs, Virginia Tech

Jacob Grohs is an Assistant Professor in Engineering Education at Virginia Tech with Affiliate Faculty status in Biomedical Engineering and Mechanics and the Learning Sciences and Technologies at Virginia Tech. He holds degrees in Engineering Mechanics (BS, MS) and in Educational Psychology (MAEd, PhD).

Dr. Holly M Matusovich, Virginia Polytechnic Institute and State University

Dr. Holly M. Matusovich is an Associate Professor in the Department of Engineering Education. She is current the Assistant Department Head for Undergraduate Programs and the former Assistant Department Head for Graduate Programs in Virginia Tech's Department of Engineering Education. Dr. Matusovich is recognized for her research and practice related to graduate student mentoring. She won the Hokie Supervisor Spotlight Award in 2014, was nominated for a Graduate Advising Award in 2015, and won the 2018 Graduate Student Mentor Award for the College of Engineering. Dr. Matusovich has graduated 10 doctoral students since starting her research program in Spring 2009. Dr. Matusovich co-hosts the Dissertation Institute, a one-week workshop each summer funded by NSF, to help underrepresented students develop the skills and writing habits to complete doctorate degrees in engineering. Across all of her research avenues, Dr. Matusovich has been a PI/Co-PI on 12 funded research projects including the NSF CAREER Award with her share of funding be ingnearly $2.3 million. She has co-authored 2 book chapters, 21 journal publications and more than 70 conference papers. She has won several Virginia Tech awards including a Dean's Award for Outstanding New Faculty, an Outstanding Teacher Award and a Faculty Fellow Award. She holds a B.S. in Chemical Engineering from Cornell University, an M.S. in Materials Science from the University of Connecticut and a Ph.D. in Engineering Education from Purdue University.

Isabel S Bradburn, Virginia Tech

Isabel Bradburn studies contexts of development and STEM education.

Dr. Cheryl Carrico P.E., E4S, LLC

Cheryl Carrico is owner of E4S, LLC. Her current research focus relates to STEM career pathways (K-12 through early career) and conceptual understanding of core engineering principles. She is currently a Member-at-Large for the Pre-college Division of ASEE. Dr. Carrico's consulting company specializes in research, research evaluations, and industry consulting. Dr. Carrico received her B.S. in chemical engineering from Virginia Tech, Masters of Engineering from North Carolina State University, MBA from King University, and PhD in Engineering Education from Virginia Tech. Dr. Carrico is a certified project management professional (PMP) and licensed professional engineer (P.E.).

Kai Jun Chew, Virginia Tech

Kai Jun (KJ) Chew is a PhD student in the Virginia Tech Engineering Education department. His research interests lie in the domains of assessment and evaluation, student learning, student motivation, and the intersections and interactions among the domains.

Ms. Michelle D. Klopfer, Virginia Tech

Geographical Inequities in Accessing Engineering and Computer Science: A State-wide Analysis of Undergraduate Enrollments Across High Schools

CoNECD Annual Meeting
April 2020

David Knight dbknight@vt.edu
Jake Grohs, Holly Matusovich, Isabel Bradburn, Cheryl Carrico, KJ Chew, Michelle Klopfer

This material is based upon work supported by the National Science Foundation (EEC-1647298). 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 NSF.

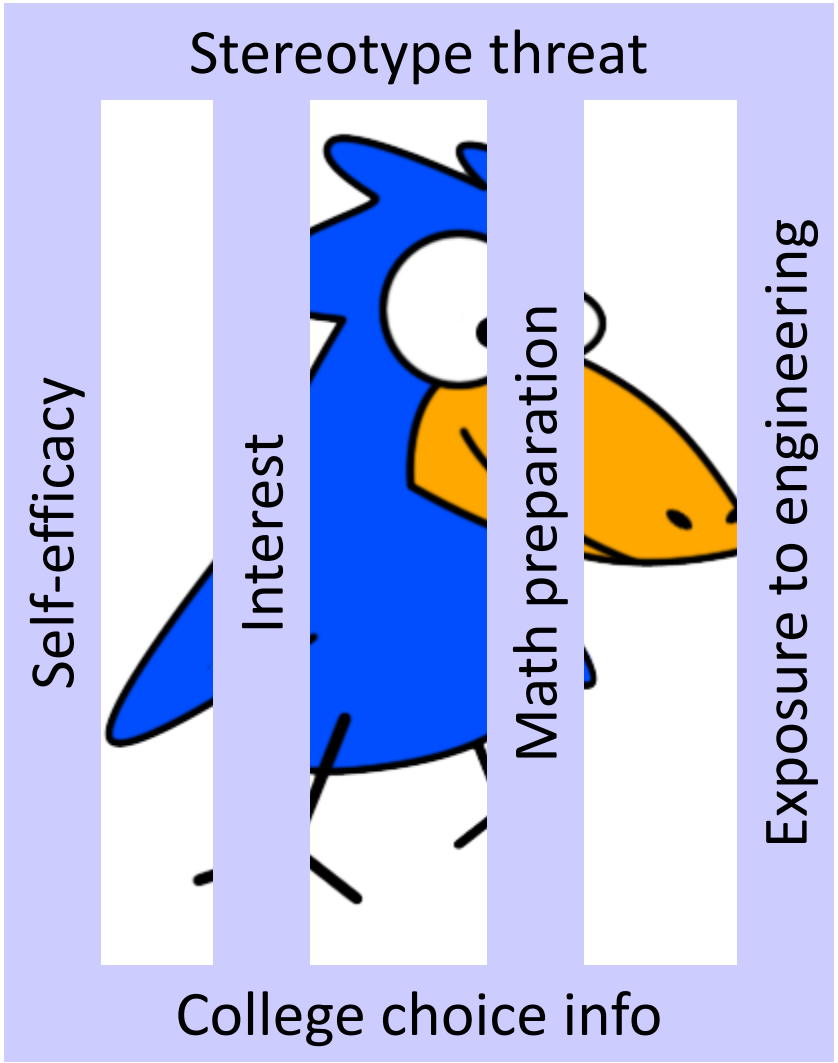
Who do we have in the room?

Brainstorm:

Who/what are gatekeepers to broadening participation in engineering?

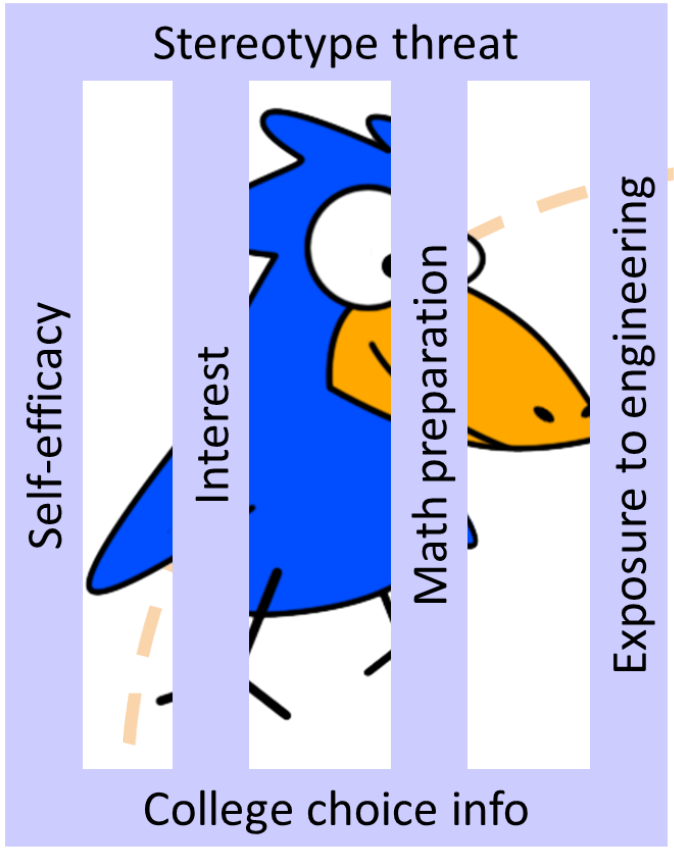
Motivation

"**Consider a birdcage**. If you look very closely at just one wire in the cage, you cannot see the other wires. . . It is only when you step back, stop looking at the wires one by one, microscopically, and take a **macroscopic view of the whole cage**, that you can see why the bird does not go anywhere . . . It is perfectly obvious that the bird is surrounded by a **network of systematically related barriers**, no one of which would be the least hindrance to its flight, but which, by their relations to each other, are as confining as the solid walls of a dungeon." (Frye, 1983)

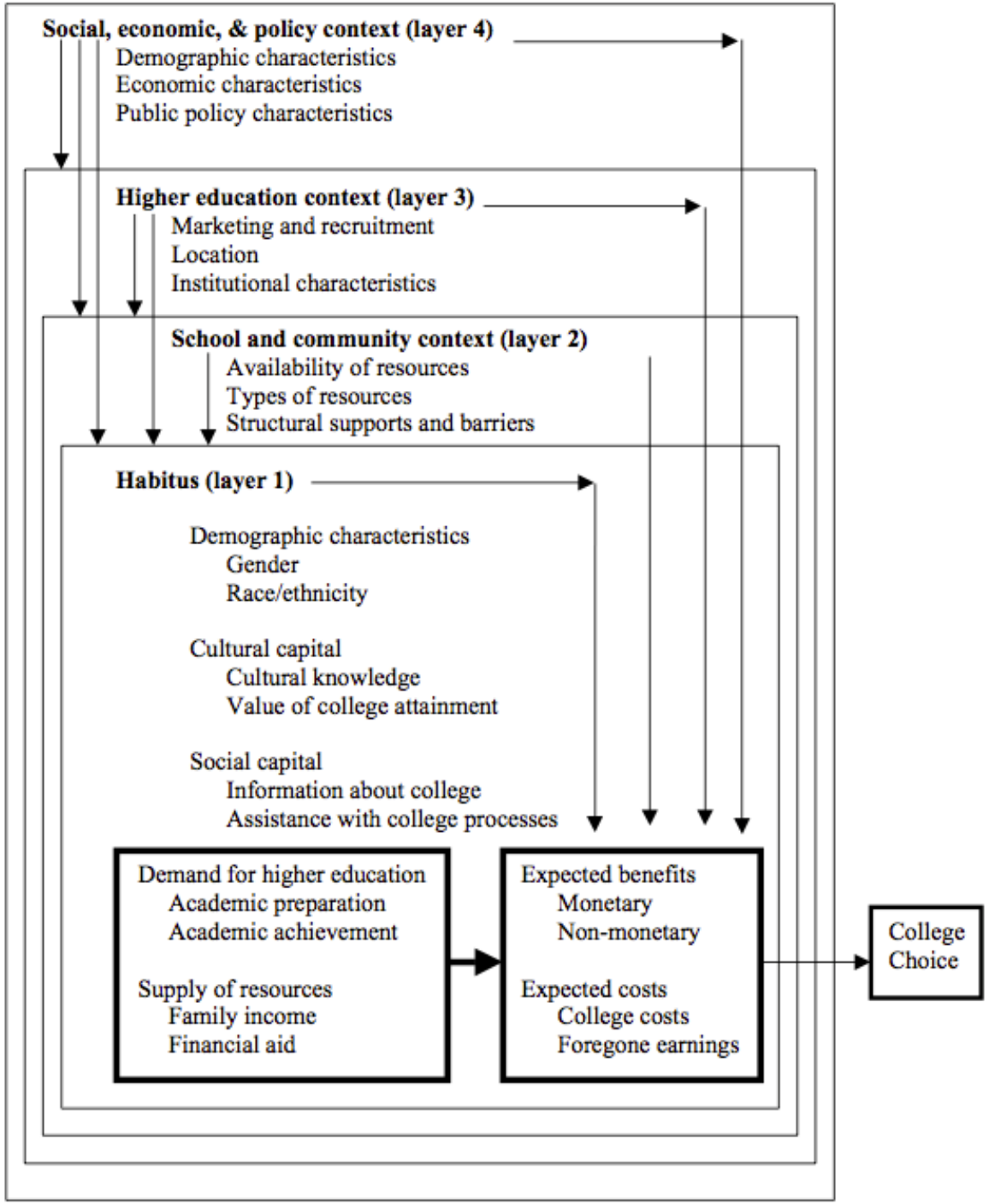

Stereotype threat
Self-efficacy
Interest
Math preparation
Exposure to engineering
College choice info

Punch Line #1

Taking a macro-scale, systemic perspective to educational research is important for understanding pressing issues in education and society, such as broadening participation in engineering.



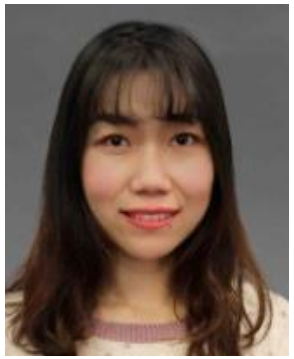
Perna (2006) Model of Student Choice



Gatekeepers to Participation in Engineering

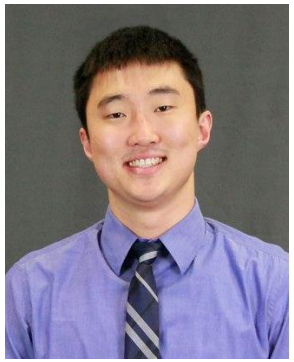


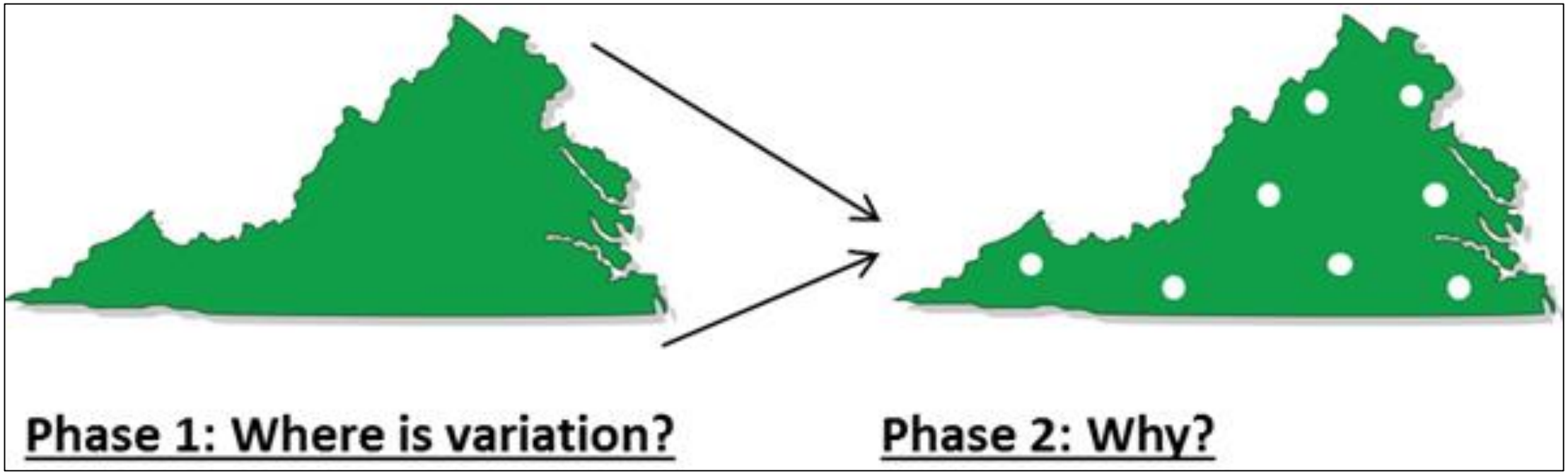




Virginia Department of Education







Phase 1: Where is variation?
Phase 2: Why?

Punch Line #2

If we want the system to change, we believe the field needs to move beyond "just" research—we should work with appropriate stakeholders to identify pragmatic implementation ideas based on that research.

And that includes you!

Virginia Longitudinal Data System

- Data across multiple State Agencies
  - Virginia Department of Education
  - State Council of Higher Education of Virginia
  - Virginia Community College System
  - Virginia Employment Commission

VLDS

Virginia Longitudinal Data System

- Student Demographics
- High School(s) Attended
- State-level Standardized Testing
- Pre-college Standardized Testing
- Advanced Placement Testing
- High School Transcript
- Postsecondary Enrollment

VLDS

Data and Methods: Quant Phase

Demographic characteristics (period of record: 2007-2014 HS graduation).

Variable	Raw Number	Percentage
Sex		
Male	342,223	49.9%
Female	343,206	50.1%
URM Status[1]		
URM	239,487	34.9%
Non-URM	445,942	65.1%
Economic Status		
Economically Disadvantaged	191,654	28.0%
Not economically Disadvantaged	493,775	72.0%

[1] Includes American Indian or Alaska Native, Black, Hispanic, Native Hawaiian or Pacific Islander, and Non-Hispanic two or more races.

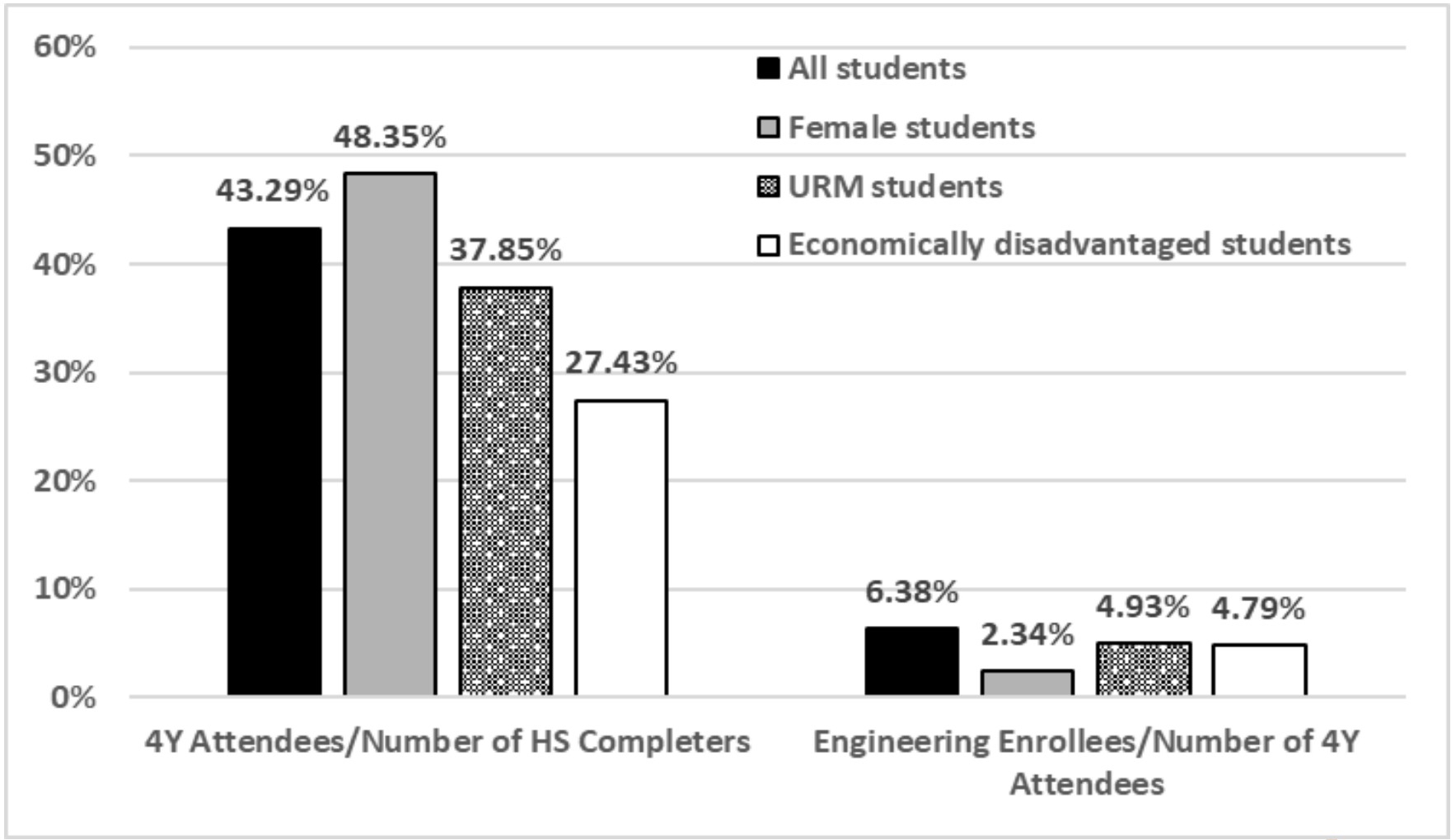
[2] Eligible for free/reduced meals, receives Temporary Assistance for Needy Families (TANF), eligible for Medicaid, identified as migrant, or experienced homelessness.

Data and Methods: Quant Phase

Postsecondary enrollment characteristics (2007-2014 HS graduation).

Variable	Raw Number	Percentage
Postsecondary Status		
4 Yr Attendee	326,979	47.7%
Did not Attend 4 Year Institution	358,450	52.3%
Engineering[1] Enrollment Status		
Engineering Enrollee	25,079	3.7%
Did not Enroll in Eng/CS	660,350	96.3%

[1] For the purposes of this study, “engineering” also encompasses computer science.


60%
50%
40%
30%
20%
10%
0%
All students
Female students
URM students
Economically disadvantaged students
43.29%
48.35%
37.85%
27.43%
6.38%
2.34%
4.93%
4.79%
4Y Attendees/Number of HS Completers
Engineering Enrollees/Number of 4Y Attendees

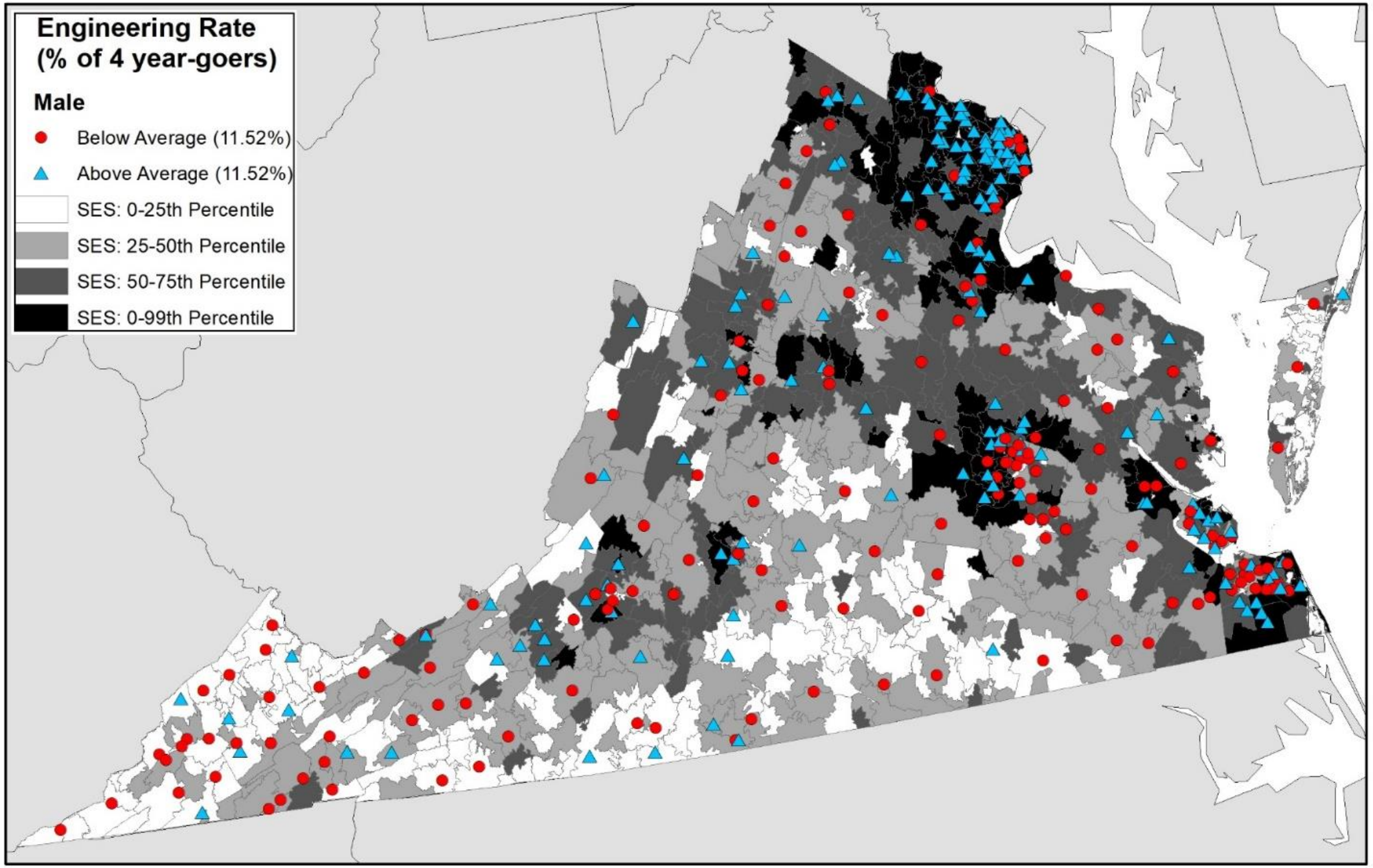
Variable	Engineering Rate
Female	**2.34%**
URM | non-URM	1.91% | 2.59%
Economically Disadvantaged | not	1.74% | 2.53%
Male	**11.52%**
URM | non-URM	8.71% | 13.04%
Economically Disadvantaged | not	9.11% | 12.17%
URM	**4.93%**
Economically Disadvantaged | not	4.30% | 5.13%
Economically Disadvantaged	**4.79%**
URM Female | non-URM Female	1.41% | 2.23%
URM Male | non-URM Male	7.73% | 11.46%

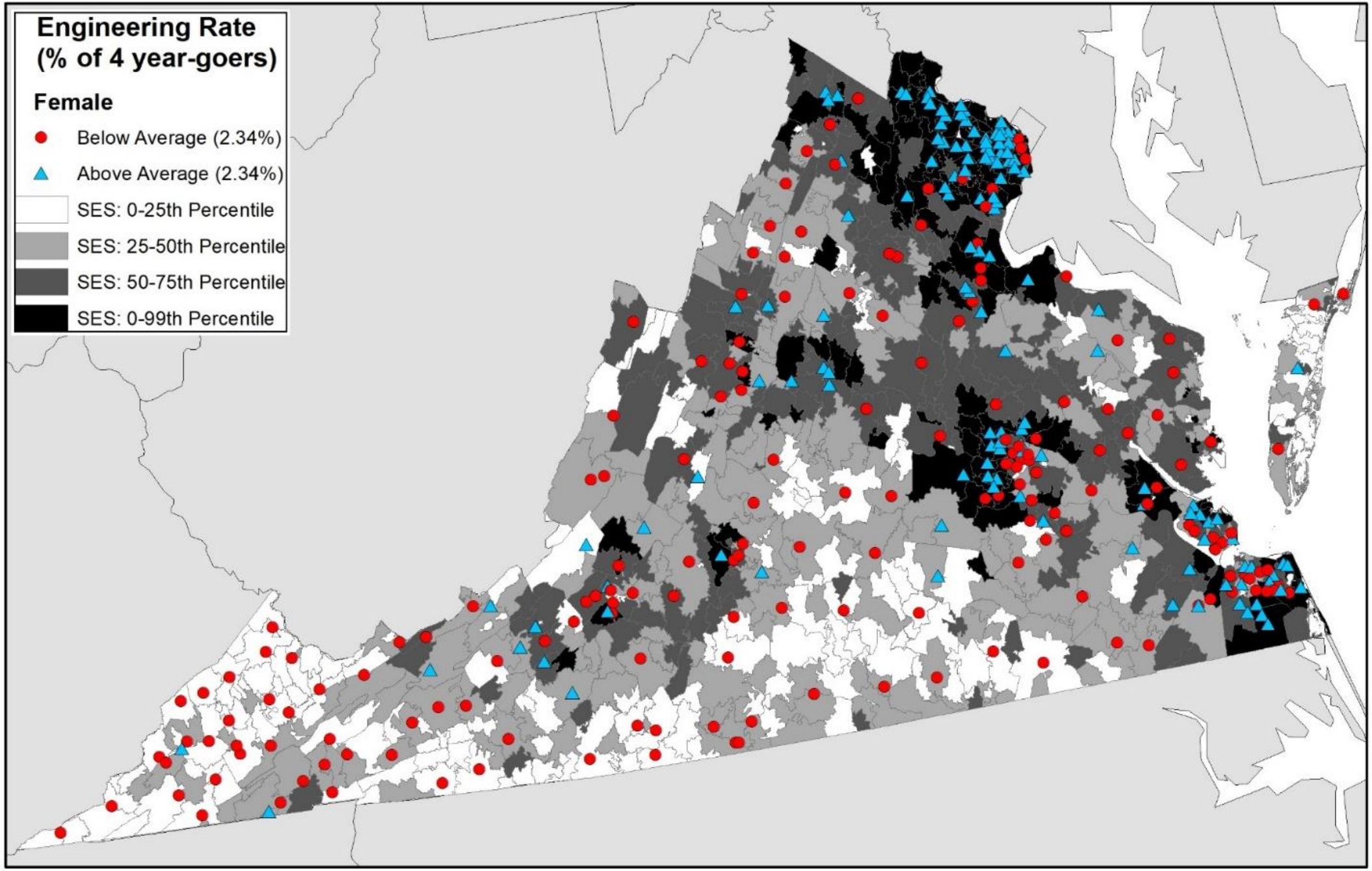
What is surprising?

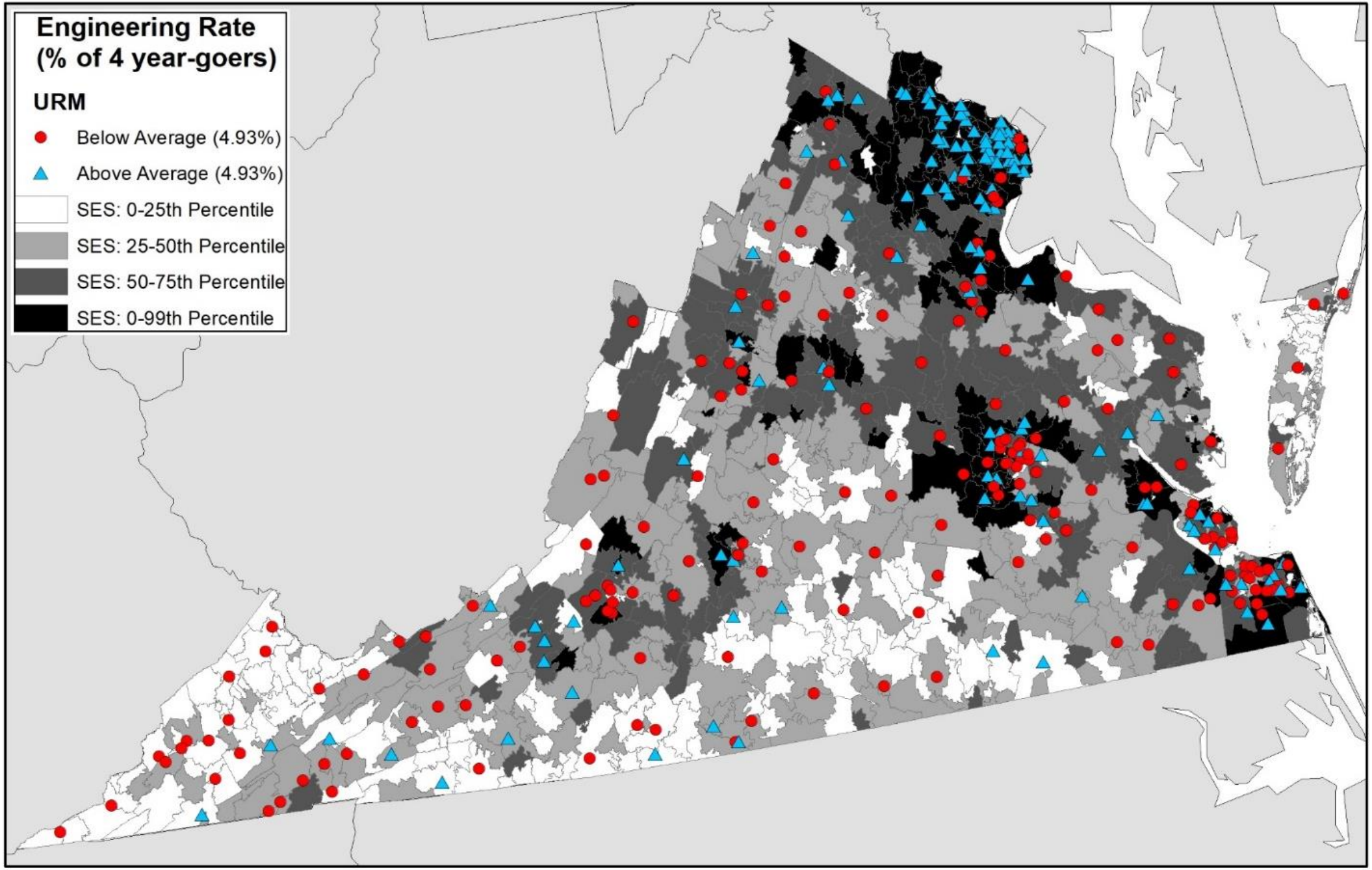
What did you anticipate?

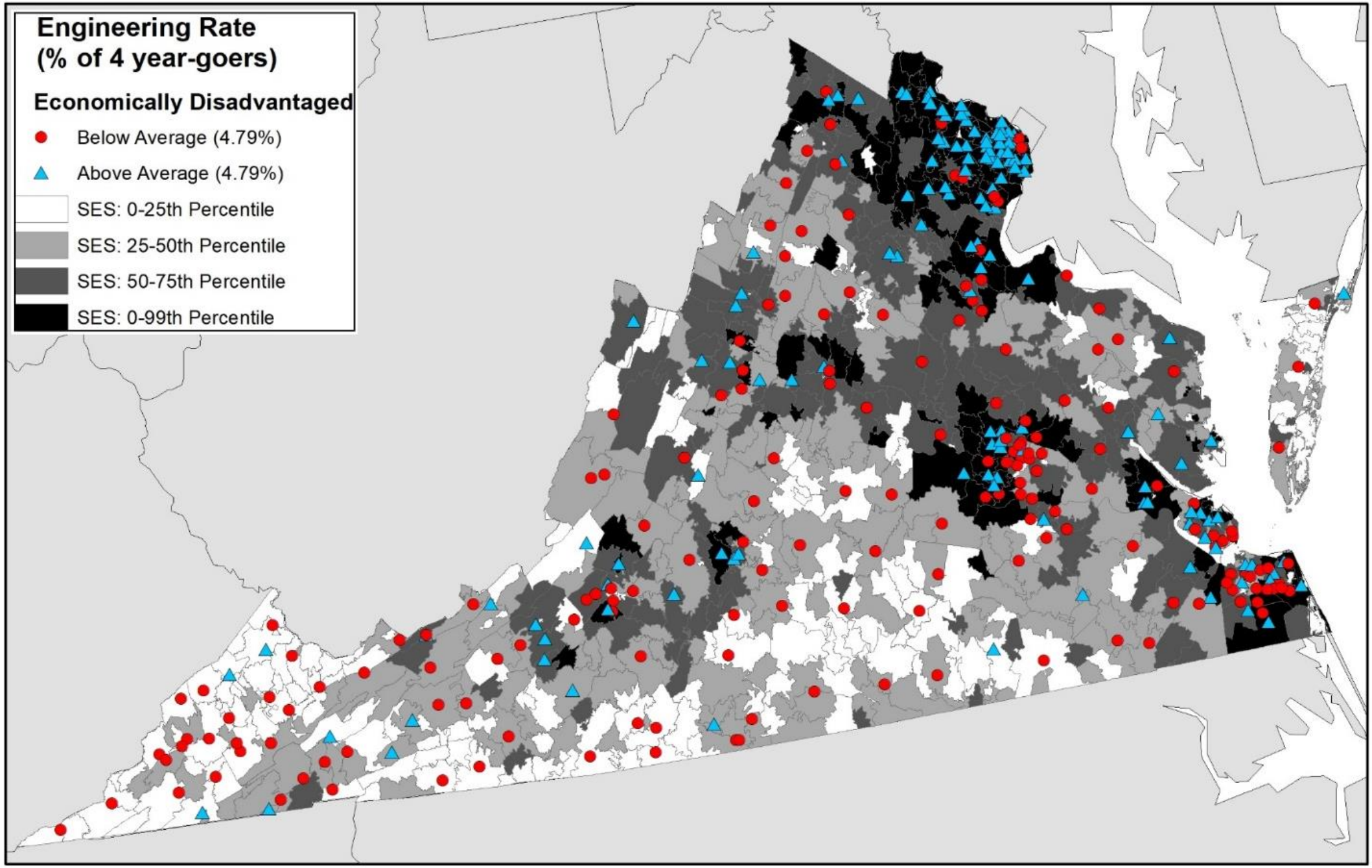
Take a guess:

How does engineering enrollment vary across Virginia's high schools from a geographic perspective?

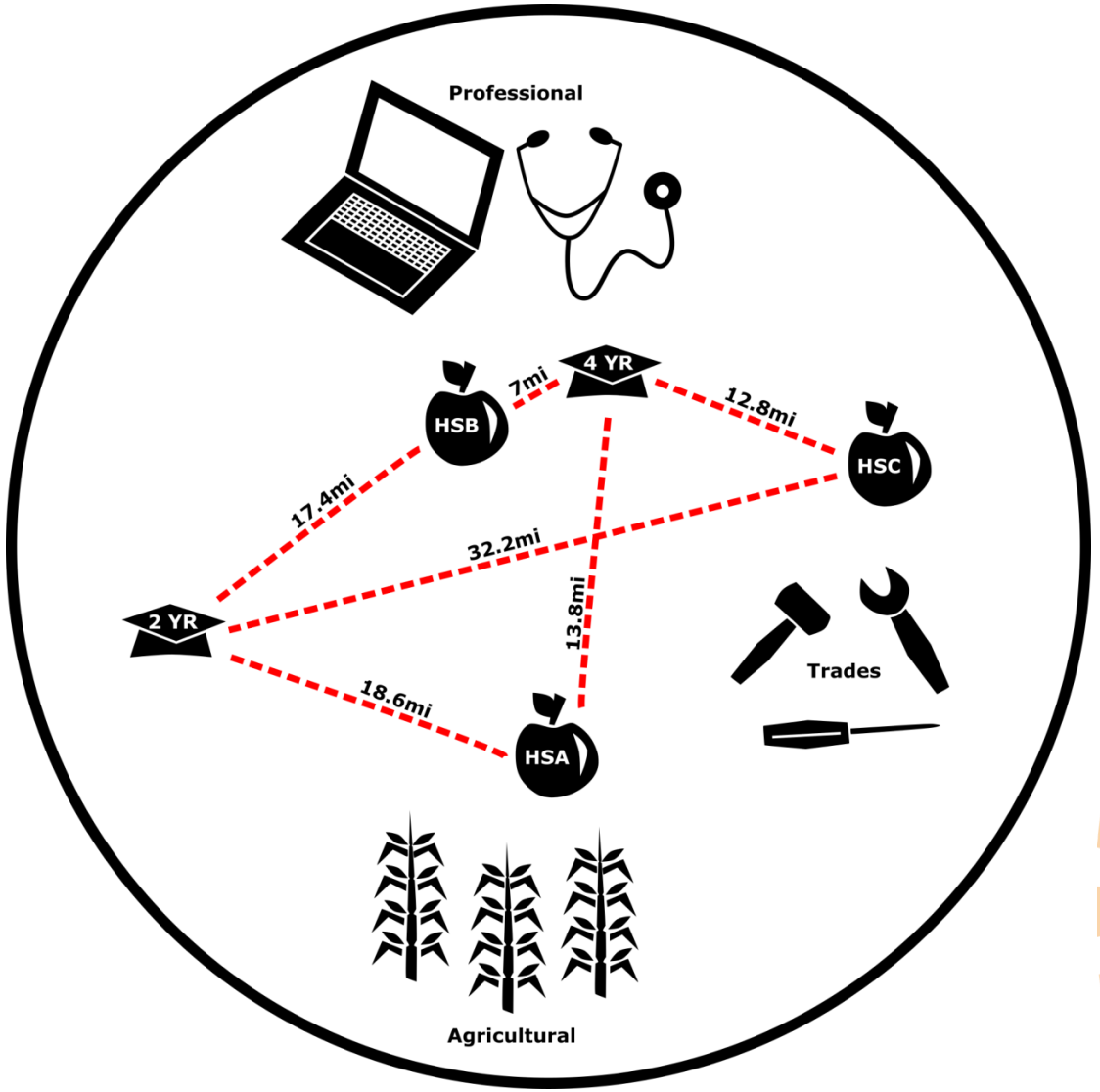

Engineering Rate
(% of 4 year-goers)
Male
Below Average (11.52%)
Above Average (11.52%)
SES: 0-25th Percentile
SES: 25-50th Percentile
SES: 50-75th Percentile
SES: 0-99th Percentile


Engineering Rate
(% of 4 year-goers)
Female
Below Average (2.34%)
Above Average (2.34%)
SES: 0-25th Percentile
SES: 25-50th Percentile
SES: 50-75th Percentile
SES: 0-99th Percentile


Engineering Rate
(% of 4 year-goers)
URM
Below Average (4.93%)
Above Average (4.93%)
SES: 0-25th Percentile
SES: 25-50th Percentile
SES: 50-75th Percentile
SES: 0-99th Percentile


Engineering Rate
(% of 4 year-goers)
Economically Disadvantaged
Below Average (4.79%)
Above Average (4.79%)
SES: 0-25th Percentile
SES: 25-50th Percentile
SES: 50-75th Percentile
SES: 0-99th Percentile

What might explain these maps?



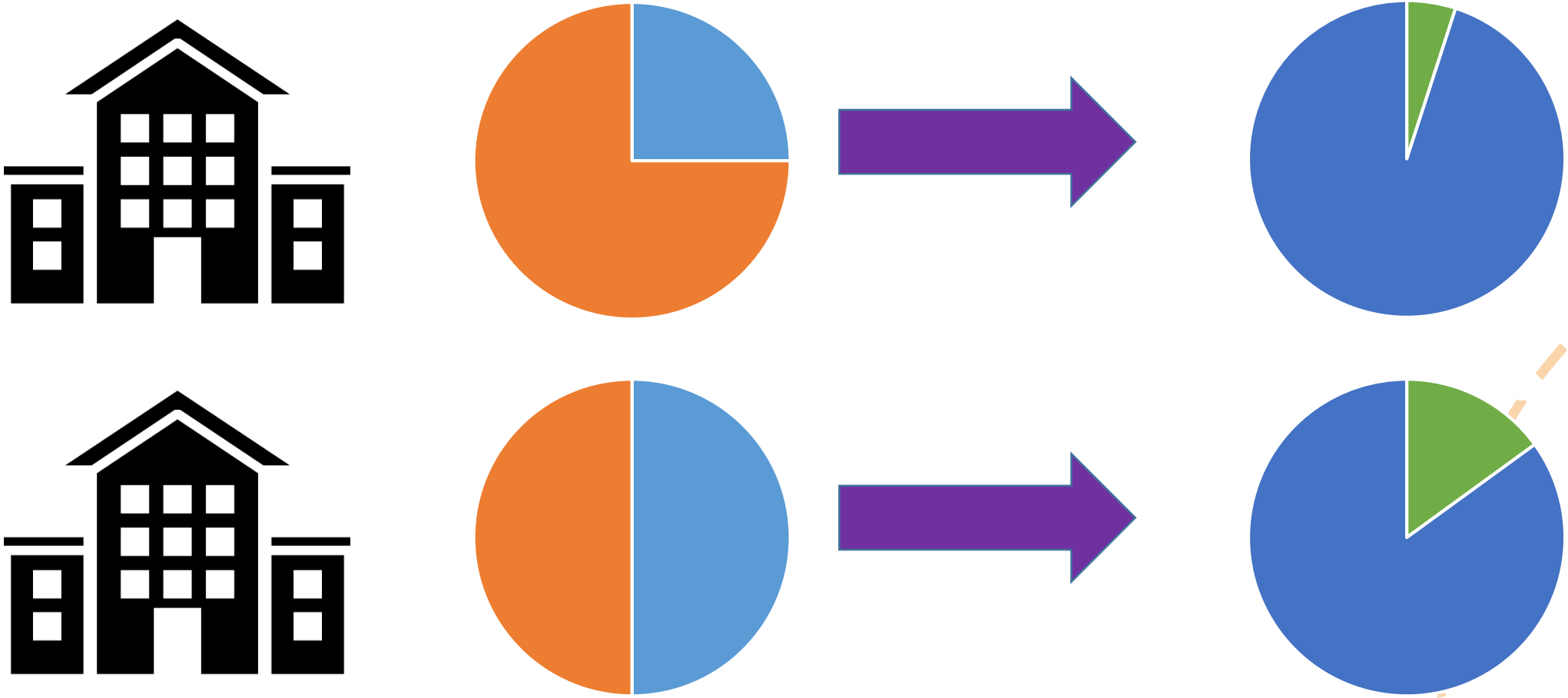
What might explain these maps? DV: Engineering enrollment

School Size		
Surrounding SES		
% 4-Year Going		

What might explain these maps? DV: Engineering enrollment

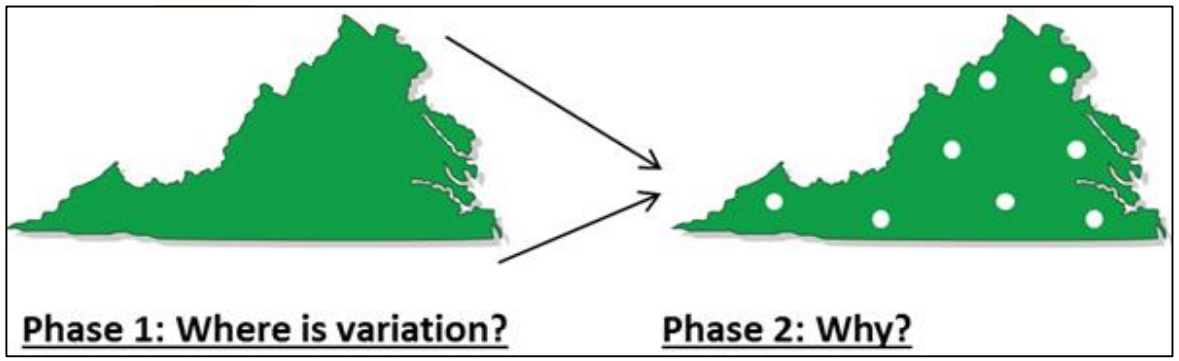
r^2 = .495	Beta	Sig
School Size	.096	.074
Surrounding SES	.229	.001
% 4-Year Going	.456	.000

What might explain these maps?
DV: Engineering enrollment

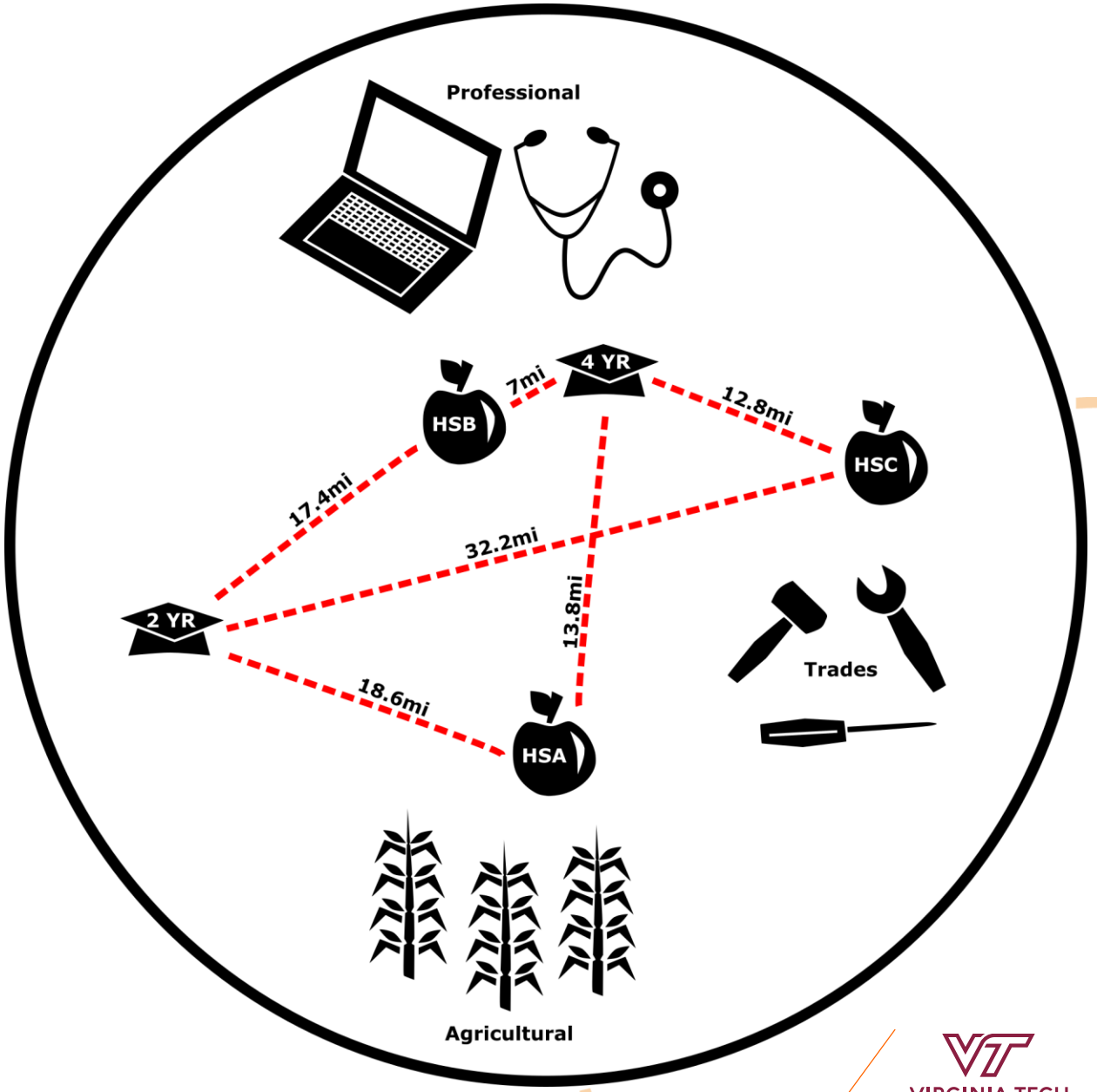


4-Year Going

Engineering Enrollment

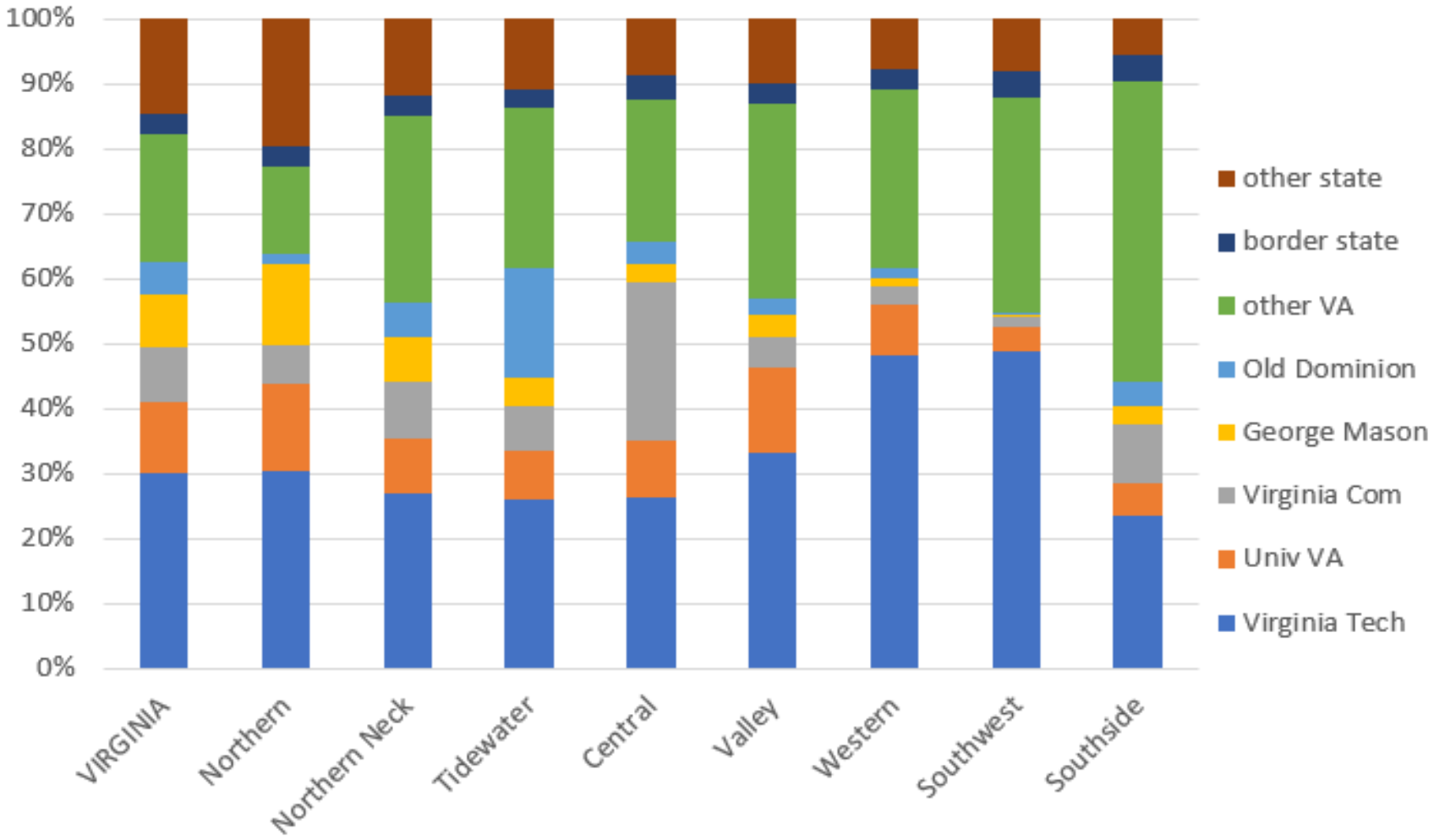


What ideas can we generate for grouping schools?

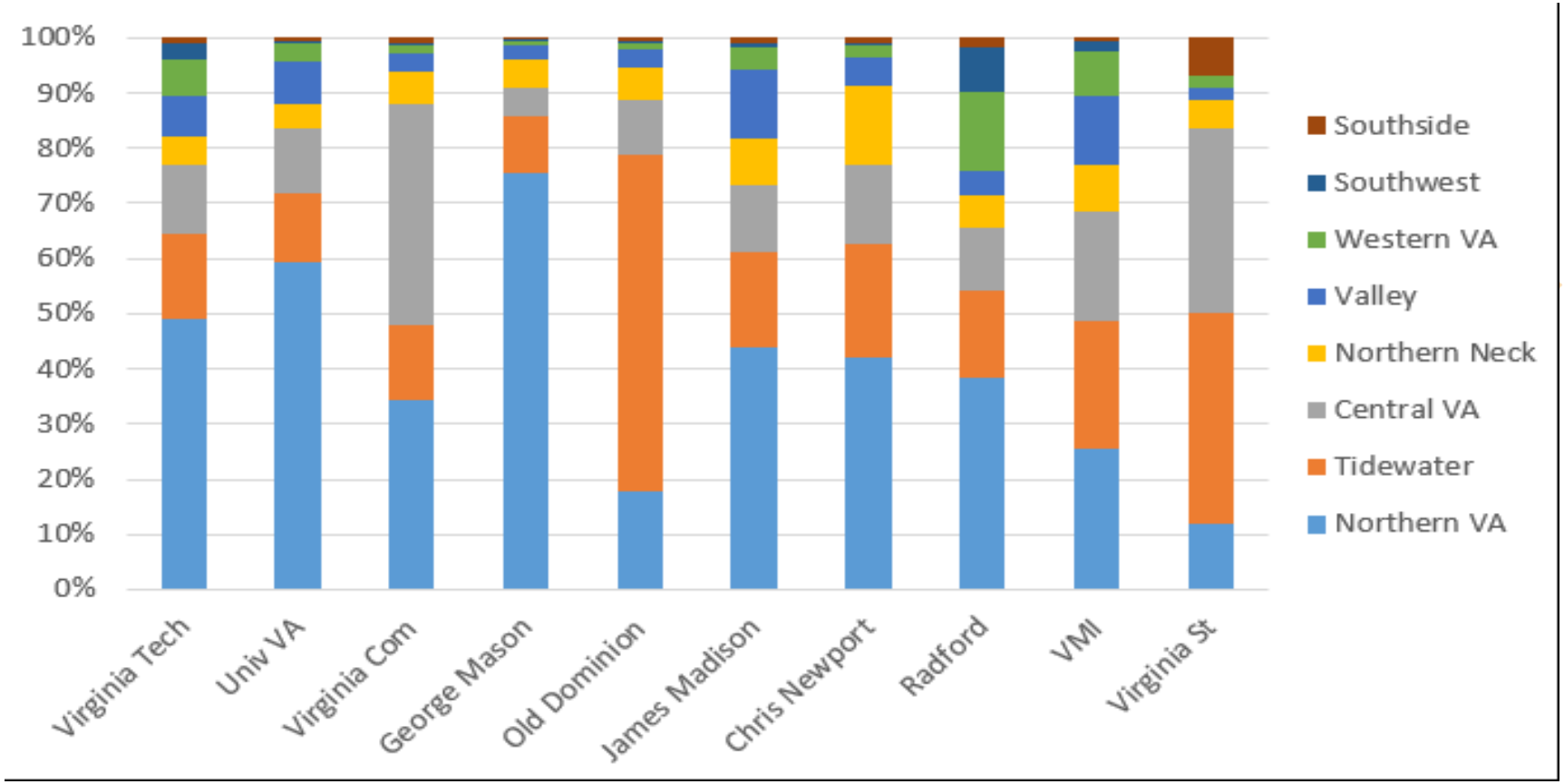


What VA universities come to mind when you hear "engineering"?

Where do Virginia students go to school for engineering by region ?

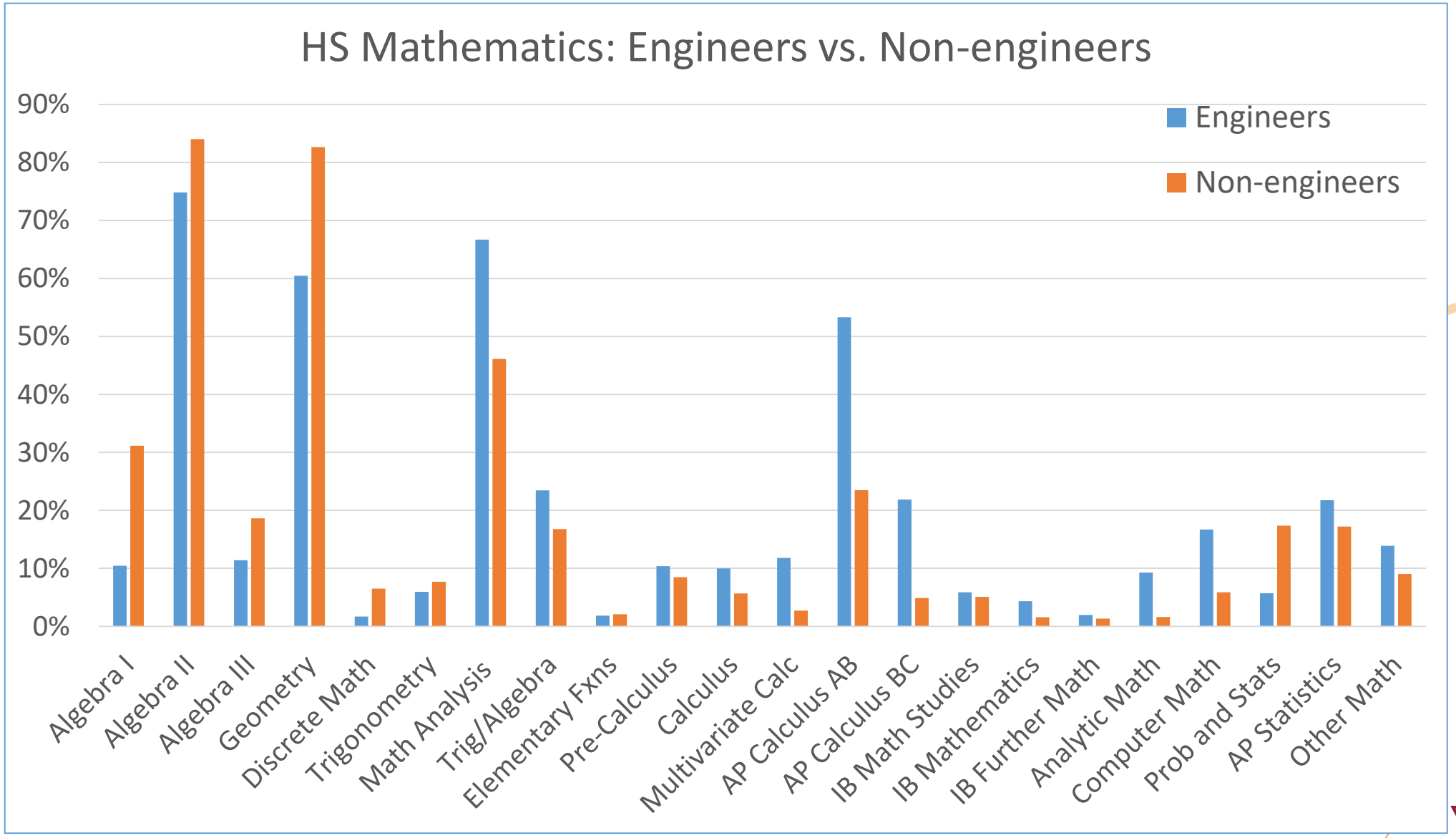


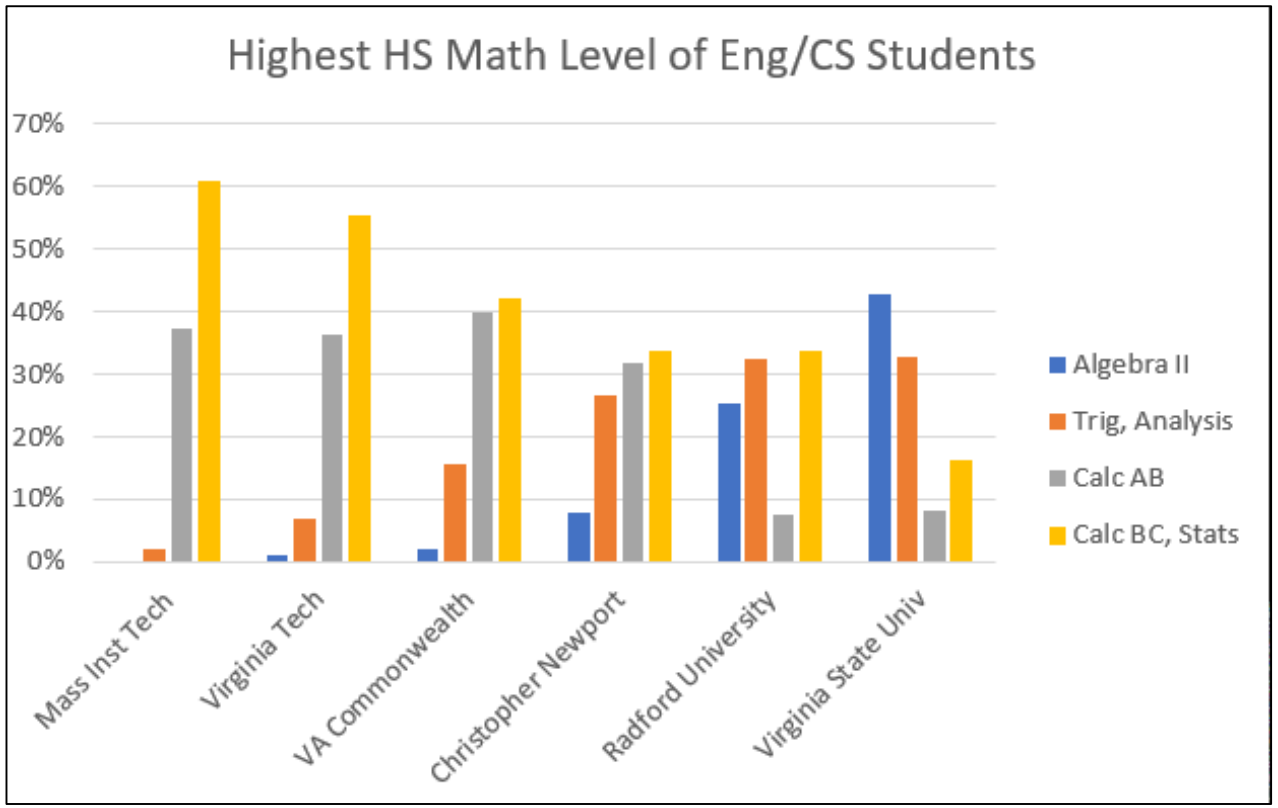
From what Virginia regions do engineering students at each of the main Virginia engineering schools come?

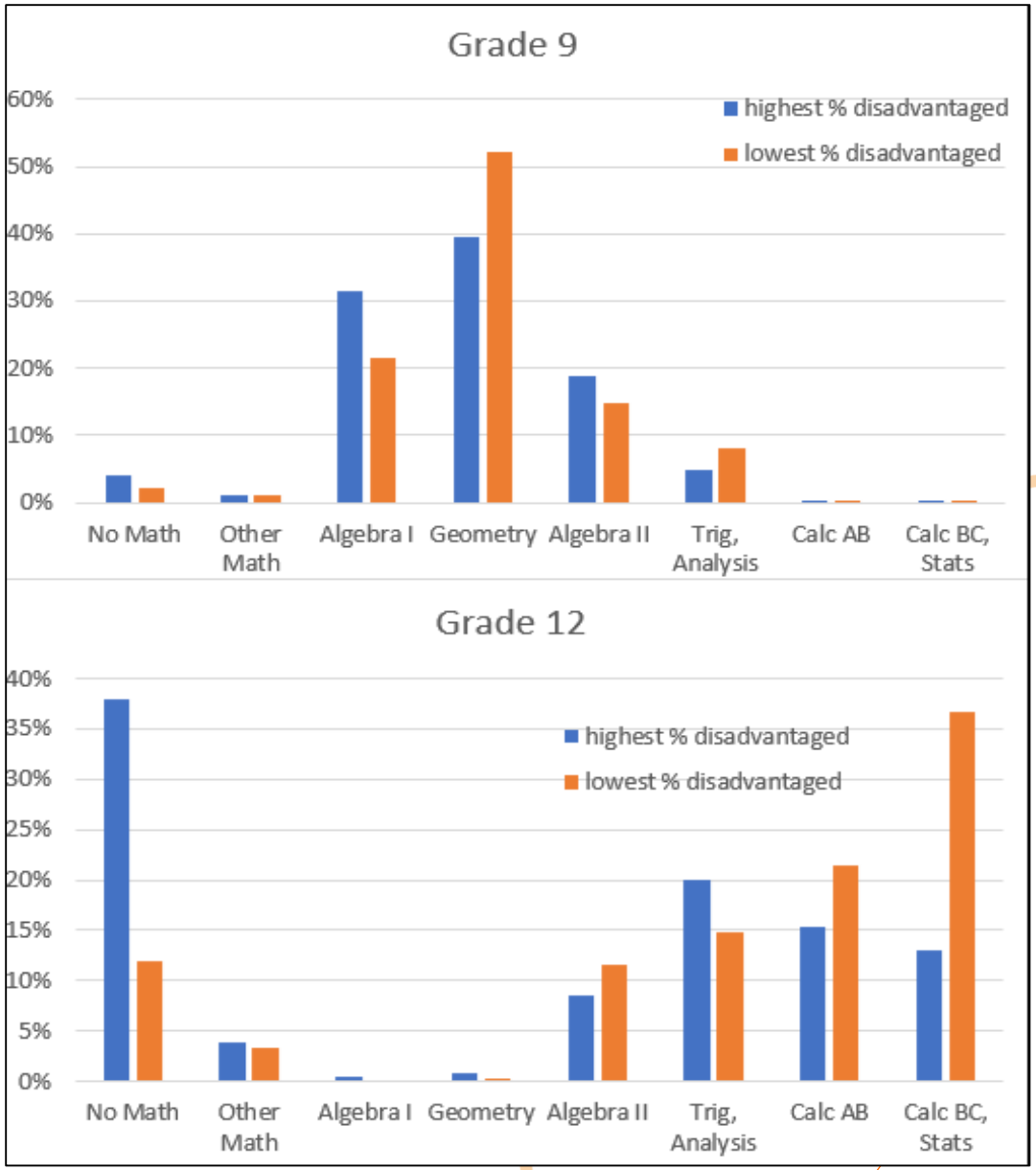


Take a guess:

What comes to mind in terms of high school math when you hear "engineering"?


HS Mathematics: Engineers vs. Non-engineers
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Engineers
Non-engineers
Algebra I
Algebra II
Algebra III
Geometry
Discrete Math
Trigonometry
Math Analysis
Trig/Algebra
Elementary Fxns
Pre-Calculus
Calculus
Multivariate Calc
AP Calculus AB
AP Calculus BC
IB Math Studies
IB Mathematics
IB Further Math
Analytic Math
Computer Math
Prob and Stats
AP Statistics
Other Math

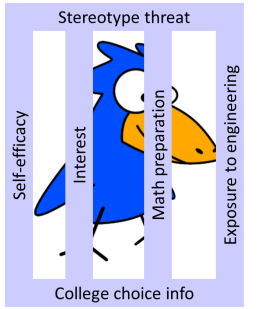

Highest HS Math Level of Eng/CS Students
70%
60%
50%
40%
30%
20%
10%
0%
Mass Inst Tech
Virginia Tech
VA Commonwealth
Christopher Newport
Radford University
Virginia State Univ
Algebra II
Trig, Analysis
Calc AB
Calc BC, Stats


Grade 9
60%
50%
40%
30%
20%
10%
0%
highest % disadvantaged
lowest % disadvantaged
No Math
Other Math
Algebra I
Geometry
Algebra II
Trig, Analysis
Calc AB
Calc BC, Stats
Grade 12
40%
35%
30%
25%
20%
15%
10%
5%
0%
highest % disadvantaged
lowest % disadvantaged
No Math
Other Math
Algebra I
Geometry
Algebra II
Trig, Analysis
Calc AB
Calc BC, Stats

Brainstorm:

What are some other questions that you have with respect to examining differences across schools related to engineering enrollments?

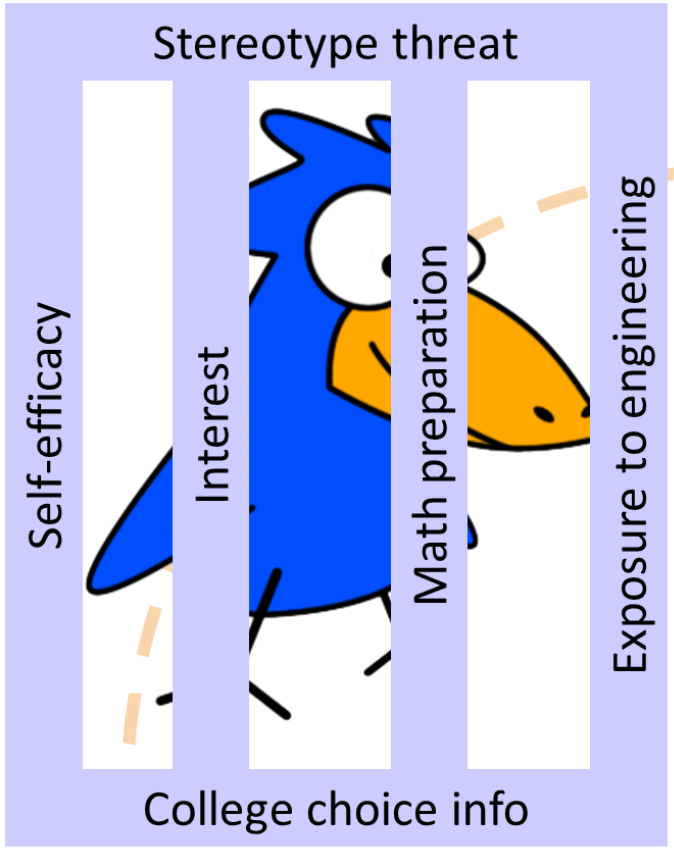
Some of Our Lessons Learned



- Administrative data are messy and complex and hard to access. Be patient, keep talking.
- High schools are a totally different paradigm from postsecondary. Each division has its own rules and cultures. And the notion of "time" is really different.
- There are systemic forces at play, which suggests inertia. But we see jolts.

Punch Line #1

Taking a macro-scale, systemic perspective to educational research is important for understanding pressing issues in education and society, such as broadening participation in engineering.



Punch Line #2

If we want the system to change, we believe the field needs to move beyond "just" research—we should work with appropriate stakeholders to identify pragmatic implementation ideas based on that research.

Geographical Inequities in Accessing Engineering and Computer Science: A State-wide Analysis of Undergraduate Enrollments Across High Schools

David Knight
dbknight@vt.edu

This material is based upon work supported by the National Science Foundation (EEC-1647298). 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 NSF.