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 currently 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 being nearly $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

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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
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CoNECD Annual Meeting
April 2020

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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)
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
Phase 1: Where is variation?  
Phase 2: Why?
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
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
Data and Methods: Quant Phase

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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Raw Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>342,223</td>
<td>49.9%</td>
</tr>
<tr>
<td>Female</td>
<td>343,206</td>
<td>50.1%</td>
</tr>
<tr>
<td>URM Status(^1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>URM</td>
<td>239,487</td>
<td>34.9%</td>
</tr>
<tr>
<td>Non-URM</td>
<td>445,942</td>
<td>65.1%</td>
</tr>
<tr>
<td>Economic Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economically Disadvantaged</td>
<td>191,654</td>
<td>28.0%</td>
</tr>
<tr>
<td>Not economically Disadvantaged</td>
<td>493,775</td>
<td>72.0%</td>
</tr>
</tbody>
</table>

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).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Raw Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postsecondary Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Yr Attendee</td>
<td>326,979</td>
<td>47.7%</td>
</tr>
<tr>
<td>Did not Attend 4 Year Institution</td>
<td>358,450</td>
<td>52.3%</td>
</tr>
<tr>
<td>Engineering(^1) Enrollment Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering Enrollee</td>
<td>25,079</td>
<td>3.7%</td>
</tr>
<tr>
<td>Did not Enroll in Eng/CS</td>
<td>660,350</td>
<td>96.3%</td>
</tr>
</tbody>
</table>

\(^1\) For the purposes of this study, “engineering” also encompasses computer science.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Engineering Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Female</strong></td>
<td></td>
</tr>
<tr>
<td>URM</td>
<td>non-URM</td>
</tr>
<tr>
<td>Economically Disadvantaged</td>
<td>not</td>
</tr>
<tr>
<td><strong>Male</strong></td>
<td></td>
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<td><strong>URM</strong></td>
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<td>not</td>
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<tr>
<td><strong>Economically Disadvantaged</strong></td>
<td></td>
</tr>
<tr>
<td>URM Female</td>
<td>non-URM Female</td>
</tr>
<tr>
<td>URM Male</td>
<td>non-URM Male</td>
</tr>
</tbody>
</table>

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:
- 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**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>School Size</td>
<td></td>
</tr>
<tr>
<td>Surrounding SES</td>
<td></td>
</tr>
<tr>
<td>% 4-Year Going</td>
<td></td>
</tr>
</tbody>
</table>
What might explain these maps?

**DV: Engineering enrollment**

<table>
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<tr>
<th></th>
<th>Beta</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>School Size</td>
<td>.096</td>
<td>.074</td>
</tr>
<tr>
<td>Surrounding SES</td>
<td>.229</td>
<td>.001</td>
</tr>
<tr>
<td>% 4-Year Going</td>
<td>.456</td>
<td>.000</td>
</tr>
</tbody>
</table>
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

- Engineers
- Non-engineers

Bar chart showing the comparison of mathematics courses taken by engineers and non-engineers.
Highest HS Math Level of Eng/CS Students

Grade 9
- Highest % disadvantaged
- Lowest % disadvantaged

Grade 12
- Highest % disadvantaged
- Lowest % disadvantaged

Bar charts showing the highest HS math level of engineering/computer science students for different institutions and grades.
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.
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.
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