Board 81: Gatekeepers to Broadening Participation in Engineering: Variation in Postsecondary Engineering-Going across Virginia's High Schools

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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 International Engagement in Engineering Education, directs the Rising Sophomore Abroad Program, 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.

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Dr. Matusovich is an Associate Professor in Virginia Tech's Department of Engineering Education. She has her doctorate in Engineering Education and her strengths include qualitative and mixed methods research study design and implementation. She is/was PI/Co-PI on 10 funded research projects including a CAREER grant. She has won several Virginia Tech awards including a Dean's Award for Outstanding New Faculty. Her research expertise includes using motivation and related frameworks to study student engagement in learning, recruitment and retention in engineering programs and careers, faculty teaching practices and intersections of motivation and learning strategies.

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Cheryl Carrico is a part-time faculty Research Scientist for Virginia Tech and owner of Cheryl Carrico Consulting, 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 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.).

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Gatekeepers to Broadening Participation in Engineering: Variation in Postsecondary Engineering-Going across Virginia's High Schools

This research stems from a project investigating gatekeepers—including the people, places, programs, and policies—that contribute to demographic variations across high schools in the proportion of students who enroll in an engineering major at a four-year university. We take a macroscopic, systemic view of an entire state's longitudinal database of high school-to-postsecondary student records to understand differences across high schools, focusing on a specific section of the pathway to an engineering career (i.e., the high school to college transition). Rather than focusing on single interventions or barriers, this research speaks to the systemic issues of access and underrepresentation in engineering and provides data related to the geographic disparities of engineering enrollment.

Leveraging the Virginia Longitudinal Data System (VLDS), a student-level administrative data set that connects Department of Education data to data collected by the State Council of Higher Education for Virginia, we are able to track each student who enrolled in a Virginia public high school into their university program of enrollment, thereby being able to characterize engineering-going pathways for the entire Commonwealth of Virginia (n=685,429 students for analyses presented). Our poster presents new results pertaining to the following underrepresented populations within engineering: women, African Americans, Hispanics, and economically disadvantaged students. We also incorporate contextual variables (e.g., average community education attainment and socioeconomic status, degree of rurality versus urbanicity) to explain some of the geographic disparities in engineering pathways, and postsecondary education pathways more broadly. Moreover, our poster presents findings from multiple cases across Virginia, where we went into high schools to interview administrators, guidance counselors, and faculty members to try to understand within-school division variation. Guided by social cognitive career theory, this qualitative data analysis unpacks the complex interactions between students' goals, interests, and self-efficacies, which are informed by a variety of contextual influences and learning experiences, and helps pinpoint why certain schools produce lots of engineers while adjacent schools may not.

Summary of Results

Both the quantitative and qualitative results point to variation between but also within school divisions in engineering yield. Considering this "gatekeeper" problem at the level of school divisions (or counties) would lose much of the variation in engineering-going between schools. We recommend keeping analyses at the individual high school level. Our poster will highlight some of the results in the following categories:

Gender and Racial Differences in Participation in Engineering and Computer Science

- We explored the idea that students with imbalanced (math-favored) achievement are more likely to major in math-intensive fields, such as engineering or computer science (ECS), compared to students with more balanced achievement profiles. To understand gender and racial differences in ECS major choices in relation to students' math and verbal SAT scores, we examined the percentage of students enrolling in ECS programs in different math and verbal score ranges, and we modeled the relationships via two logistic regression analyses.

- Our findings suggest that when scoring within the same math and verbal SAT score ranges, males were more likely than females to choose ECS programs as their college majors for both URM and Non-URM students. However, for both Non-URM females and males, when they had the same math scores, they were less likely to enroll in ECS programs if their verbal scores were higher compared to if their verbal scores were lower. It appears as if students with both high math and high verbal scores may have a greater variety of options or interests for other majors.
- The exception to this overall pattern is for underrepresented women of color. For these students, verbal scores appeared largely independent of their propensity to major in ECS. Specifically, these students with high verbal scores (601 to 800 range) were more likely to enroll in ECS programs compared to their majority female peers with similar math-verbal score profiles. The percentages of URM male students who scored within the same math range and enrolled in ECS programs were similar within each math range when their verbal scores were in the range of 501 to 600 and 601 to 700. When their verbal scores were within the range of 701 to 800, the percentage of them majoring in ECS programs was lower compared to those whose verbal scores were lower.
- Overall, we found that URM students were as likely, if not more likely, than Non-URM students to choose ECS programs when they had similar levels of math and verbal SAT scores. However, URM students' average SAT scores were lower than Non-URM students' scores (there is a broad literature offering potential explanations). Thus, our results suggest that if programs do not de-emphasize SAT scores during admissions decisions or if more systemic issues of resource allocation in secondary school are not addressed, efforts to broaden the participation in ECS programs may fall short of goals.

Geographical access to engineering: Variation in enrollment in undergraduate engineering programs from Virginia's high schools

- We took a macroscopic, systemic view of an entire state's longitudinal database of high school-to-postsecondary student records to understand how each high school performs in sending its students into engineering. We also explore how that engineering enrollment rate varies across different demographic characteristics, including gender, race/ethnicity, and socioeconomic status. At its core, this analysis illuminates inequality in enrollment in bachelor's of engineering (and computer science) programs across high schools in an entire state. This largescale view depicts how variables systematically related to high school context or geography can act in combination to be a barrier to enrollment in engineering programs.
- Across all high schools in Virginia, four-year college going rates are as follows: 43.29% for all students, 48.55% for female students, 37.85% for URM (based on race/ethnicity) students, and 27.43% for economically disadvantaged students. Of the students who attend a four-year institution, the percentages who enroll in engineering (at any point) across high schools are as follows: 6.38% for all students, 2.34% for female students, 4.93% for URM students, and 4.79% for economically disadvantaged students. Thus, our results show that all underrepresented groups are below the share of engineering-going for all students, but females in particular are the group least represented among four-year college-goers. That under-representation becomes magnified for intersections of the demographic variables, but "female" is the largest determining factor.

- There is a weaker relationship between school size and engineering-going than there is for school size and four-year college-going. Schools that are above the state-average for four-year college going are below the state average for engineering-going and vice versa. Thus, we can conclude that different factors are at play that influence engineering-going versus four-year college going across high schools.
- There is high geographic variation in the engineering-going rate from high schools across the state. The northern Virginia area in particular as well as some schools around the Richmond area and Tidewater area are the major engineering-producers in the state, and schools in more rural and urban areas tend to not produce as many engineers of the four-year going population. There are some notable exceptions, however, which our future research seeks to explain.
- We found a moderately strong correlation between a high school's zip code-level socioeconomic status variables (i.e., in this case percent of citizens with a bachelor's degree and median income level) and the engineering-going rate as well as the four-year college going rate. This finding suggests that engineering-going is tied to non-random distribution of social structures and factors such as resource availability in different high schools. We argue that sustainable shifts in broadening participation in engineering must come from a systemic perspective that engages state-level partners (e.g., the Virginia Department of Education) who may be able to influence disparities between schools.

Qualitative Analysis

- One of our case study sites focused on two elements of Social Cognitive Career Theory (SCCT), including outcome expectations and environmental influences, and specifically on the socializer perspective. This means that we examined what outcomes socializers thought students were aiming for and what environmental factors socializers describe as salient to those outcomes.
- With regard to outcome expectations, we found differences across schools with regard to the salience of higher education broadly and specifically engineering. With regard to environmental factors, we identified five factors perceived by socializers to influence postsecondary enrollment in college (and by default engineering) including: 1) proximity to post-secondary schooling, 2) parent and family background (typical work in the area), 3) tuition support programs, 4) funding or program availability at the high school, and 5) the role of counselors and teachers. Although common in name, these factors are generally experienced differently at the different schools with a few similarities.

Our project demonstrates that it is imperative to address issues of broadening participation from a systemic perspective in consultation with state-level partners in the Department of Education. We offer ideas for engaging school districts as well as state agency partners that should be of interest to researchers in the broadening participation space.

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