Gatekeepers to Broadening Participation in Engineering: A Qualitative Investigation of a Case Site in Virginia (Work in Progress)

Mr. Andrew L Gillen, Virginia Tech

Andrew Gillen is a doctoral student and graduate research assistant in the Department of Engineering Education at Virginia Tech. Andrew received his B.S. in Civil Engineering with an environmental engineering concentration from Northeastern University.

Dr. Cheryl Carrico P.E., Virginia Tech

Cheryl Carrico is a Research faculty member for Virginia Tech. Her current research focus relates to STEM career pathways (K-12 through early career) and conceptual understanding of core engineering principles. Dr. Carrico owns a research and consulting company specializing 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.).

Dr. Holly M Matusovich, Virginia Tech

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.

Gatekeepers to Broadening Participation in Engineering: A Qualitative Investigation of a Case Site in Virginia (Work in Progress)

Abstract

To broaden participation in engineering, there is a need to move beyond examining the variables that differentiate underrepresented students from majority students and take a systemic approach. As part of a larger project, this research begins closing that gap by examining systemic variables that influence enrollment in 4-year University engineering programs. Situated in Social Cognitive Career Theory (SCCT), this work in progress analysis examines interviews with principals at a single case site to identify proximal and distal influences on engineering career choice pathways. In addition to identifying factors consistent with current literature, this analysis expands current literature by articulating how the same factor can be perceived differently within different schools in the same case site region.

Introduction

Determining the causes of persistent underrepresentation remains a continued challenge for researchers in engineering education. Much of the current research has focused on specific variables that differentiate these students from majority populations in engineering (Carrico, Matusovich, & Paretti, 2017; Garriott, Raque-Bogdan, Zoma, Mackie-Hernandez, & Lavin, 2016; Kim & Seo, 2014). While important, this approach is limited with regard to ability to inform systemic change as it represents a singular perspective. Moreover, literature clearly identifies other stakeholders, such as parents and teachers, in students' choices to pursue engineering careers (Dick & Rallis, 1991; Garriott et al., 2016; Martin, Simmons, & Yu, 2014; Matusovich, Carrico, Paretti, & Boynton, 2017; Simmons & Martin, 2014). Therefore, a broader, systemic perspective is needed that encompasses multiple perspectives. To enable a systemic perspective, we have undertaken a research project which starts at the high school level and considers how factors impact enrollment in engineering majors vary systematically across an entire state. Specifically, this work in progress (WIP) paper focusses on interviews with principals at a single case site to answer the research question: From the principal's perspective, what high school level local and contextual factors contribute to the variation in enrollment into 4-year University engineering programs? Our case site was selected based on results of the first phase of the study which leveraged the Virginia Longitudinal Data System (VLDS), a compilation of student-level data from all Virginia K–12 students (e.g. student demographics, high school attended, standardized testing, course enrollment, AP test scores, postsecondary program of enrollment) to identify systemic patterns in engineering enrollment. We used interviews to ask principals about supports and barriers to students from their schools enrolling in 4-year engineering programs. We grounded our analysis in Social Cognitive Career Theory (SCCT), and specifically the constructs of proximal and distal contextual affordances, as a way to identify the principals' perspectives on influencing factors.

Background and Framework

Social Cognitive Career Theory (SCCT) (Lent, Brown, & Hackett, 1994, 2000) describes the relationship between person, environment, and behavior relative to career choices. SCCT

identifies processes and resulting pathways through which students form academic and career choice goals and make decisions regarding necessary actions to attain their goals. Specifically, SCCT posits that students will base their career choice on having 1) the skills and knowledge for the career, 2) the expectations of the reward for the career, 3) an interest to do the work related to the career, and 4) a supportive climate for pursuing the career. In particular, the supportive climate is based on environmental influences which can be proximal (i.e. direct and immediate) to the career choice decision-making or distal (background) and can be documented (e.g., financial status) or subjective (e.g. perceived support or limitations such as gender bias or discrimination) and are affected by an individual's interpretation (Lent & Brown, 1996). From a distal perspective, these influences/influencers may shape a student's interests or self-efficacy as well as provide cultural and gender socialization acumen. In contrast, proximal influences are those which exist during the decision-making process (Lent et. al., 1994) and may include career networking or barriers such as discrimination. Important to this WIP, SCCT recognizes that people can be import influencers of career choices (both proximal and distal). These potential influencers' perceptions of students' decision-making processes provides valuable insight in understanding how and why influencers themselves make certain decisions that can, in turn, affect students' decision-making processes.

Methods

This WIP analysis is part of a larger three-phased, mixed methods research study. Phase 1 identified two major geographic regions (cases) for site selection based on the combination of their student demographics and patterns of postsecondary enrollment (Gillen et al., 2017). In this WIP study, we will present preliminary findings from the qualitative phase two, which is further scoped to principal interviews in one of the case study sites. To frame the preliminary exploration for phase two, we posed the following research question: From the principal's perspective, what high school level local and contextual factors contribute to the variation in enrollment into 4-year University engineering programs?

Site and Participant Description

Three schools are under investigation in this WIP study: High School A (HSA), High School B (HSB), and High School C (HSC). The case site that encompasses these three high schools is a primarily rural geographic region. U.S. Census (2016) indicates the county containing these high schools has a population of approximately 80,000 - 120,000 and a median household income of $40,000 - 60,000. Ranges were reported instead of the actual values to obscure the identity of the county. Based on the ranges of secondary school size provided by Grauer (2012), HSA and HSB can be characterized as large public secondary schools (750+ students), and HSC can be characterized as a small public secondary school (3 - <400 students). To develop a sense of relative socioeconomic status for the areas, the percentage of students receiving free or reduced school lunch can be used as an indicator. Precise statistics were obtained from the Virginia Department of Education (2017), but to protect the identity of the schools and participants, the percentages are presented in ranges: HSA (30% - 40%), HSB (10% - 20%), and HSC (50% - 60%).

According to Yin (2003), a case study may have more than one unit of analysis, and the principal is an embedded unit within our case (geographic region). The principals of the three high schools have been employed in their positions from one to as long as nine years. Their teaching and previous leadership backgrounds are equally as diverse. Collectively, the principals have had prior experiences as both elementary and secondary teachers and in other administrative roles before transitioning to high school principalship.

Data Collection and Analysis

To address the research question, we invited all principals from our case site to participate in single 30 to 60 minute semi-structured interviews. Three principals responded, all in the affirmative. The interview protocol was informed by conversations with the quantitative phase team and insights from the literature about possible systemic issues preventing particular students from enrolling in a 4-year engineering program as a postsecondary pathway. We asked each principal about possible career pathways their students are likely to take (including engineering specifically), perceptions of student preparedness for engineering careers, perceptions of how their students think about engineering careers, and finally thoughts on the supports or barriers at the school or state level relative to students pursing engineering careers. The interviews were transcribed verbatim. We drew on the qualitative analysis guidelines from Miles, Huberman, and Saldaña (2013). Codes and example quotes are shown in Table 1.

Note, we consider the proximal and distal influence constructs from the SCCT framework together in this analysis. Many of the principals spoke about their student population at a high level, and it was challenging to establish the temporal component required for distinguishing distal and proximal influences. As a result, this analysis combines proximal and distal influences together and considers similarities and differences across participant responses.

Table 1. Preliminary codebook with example quotes.

Code	Example Quote
Parent worked as an engineer	It's large with engineering at [university 1]. So I'd guess there's probably a fair amount of kids. A handful of students that have some kind of connection with their parents being engineers here. (HSA Principal)
Proximity to institution of higher education	Huge, huge advantage for where we are geographically, even within our own county. Kids are naturally advantaged because of our proximity to [university 1], and even kids in this region are advantaged by their proximity to [university 1] and [university 2]. Having a community college that's 20 minutes away is another huge benefit. (HSB Principal)
Funding or program availability	Where I see barriers is not so much in the policies but in the physical plan of the building. (HSC Principal) But there's some students that don't want to travel because they enjoy being here with their friends all day. Losing those two credits can be a powerful thing because a lot of them are college-bound, and they want to try and earn as many credits as they can to prepare themselves for college. (HSA Principal)
Student engineering knowledge	I don't know how many students really know what engineering is and what jobs are out there. I'm sure they've heard of the word, and they have some kind of idea, but what does that really mean. That's probably a barrier. (HSA Principal)

Results and Discussion

Given the preliminary nature of this as a WIP, we are continually iterating between our findings, their interpretation, and what it all means for the study as a whole. Therefore, we have intentionally combined our results and discussion into a single section. In comparing and contrasting what the principals reported as influences within our case, but across interview participants, we found that our list of influences both confirms and extends current literature. One particularly important result of our analysis is that when we consider patterns in the influences, we found that a focus on specific or individual influences may have a significant impact on whether students choose engineering careers or not.

Consistent with current literature, we found that principals generally believed that students' choices to pursue engineering would be influenced by having a parent that worked as an engineer (Martin, Simmons, & Yu, 2014; Schreuders & Mannon, 2007), being in proximity to a four-year school (Turley, 2009) or having funding/program availability at the high school (Matusovich, Carrico, Paretti, & Boynton, 2017). Although only cited by one participant, the idea of needing to know what engineering is to even pursue an engineering degree is also represented in current literature (Matusovich, Streveler, Miller, & Olds, 2009)

While these factors themselves are not new, we identified nuances that emerged through our ability to compare across different schools in proximal locations with different resources as described in the methods. For example, we confirmed findings from literature that people matter (Boynton, 2014; Carrico, Murzi, & Matusovich, 2016). However, nuanced in our data set is that despite the schools' proximity to one another, the ways people talk about people is different across the schools. When asked if there were teachers that talked to students about engineering, the HSB principal noted several math and science teachers including a calculus teacher with an engineering background as particularly influential. He explained,

> [Teacher name], that teaches our Calculus upper level math classes... He absolutely talks to kids about engineering. [Teacher name], our physics teacher, she absolutely talks about it, she's got a lot of kids that are interested in engineering...kids gravitate towards those folks with their questions. (HSB)

We believe this a particularly important pattern to note because we wondered what happens if this person leaves; what happens to career pathways? Relying on specific individuals, versus a culture of awareness, may result in temporary or fluctuating support toward engineering career awareness.

Conversely, a school's culture toward engineering or even post-secondary education may provide a more lasting support or barrier toward students' career choice goals and actions. For example, at HSA, the principal makes a distinction between individuals that are influential for students in choosing careers versus colleges. He emphasizes career and technical education teachers (CTE) and the school counselor in contrast to the upper level math and science teachers identified by the HSB principal. The principal said,

> Our school counselor is probably pretty beneficial to students in terms of, I don't know maybe career-wise, but at least college-wise. What happens next. Where we want to go. I probably say our CTE, our career and technical education teachers probably play a pretty big role with students in terms of careers. Ideas like what

> they want to get into. Our goal is to try and expose students to as many things as possible so they have an idea of what else is out there. I would say probably our CTE department and our school counselor are probably the biggest influences there. (HSA)

We noted that the HSA principal spoke in terms of his school's goals and referenced the CTE department (teachers) and not individuals, suggesting more of a culture or resource within the school than an individual's influence. Because the focus is not in individuals, the proximal support through HSA may be more stable. At the same time, it may be less personalized or engineering specific.

Similarly, we found nuances in how principals talked about the same program or types of programs. For example, comparing two principals that mentioned the Access to Community College Education (ACCE) program which provides qualifying students (GPA>2.5 and 80 hours/year community service) with free tuition for two years at the local community college. At HSB which is higher resourced and serving a more affluent population, the principal praised this program as a means to support students that might otherwise fall through the cracks of the academic system. He commented,

> My goodness. What an unbelievable opportunity we've created for kids who have never seen a road map that took them anywhere other than working at a dry cleaner's the rest of their life. (HSB)

At HSC, however, ACCE was seen as a way to support promising students.

> I'm really hopeful that the ACCE's program that [school county] is starting this year will have an impact on our kids and we'll get even more kids going to [community college]. (HSC)

All of the principals interviewed saw value in the ACCE program, however, what the value is differed. This nuance between the principals' comments on the same program illustrates the importance of Lent and Brown's (1996) argument to unravel the specificity of proximal supports and barriers and understand their context.

Across the data was a theme of wanting to support students. However, the principals' apparent expectations of students, and how to best support them, varied. One of the variation patterns involved school resources (e.g., advanced subjects) and, as noted in our codebook, students potentially opting out of advanced math and physics courses in order to have added high school credits. Interestingly, it was those courses at HSA where some students learn about engineering.

Limitations, Conclusions, and Future Work

Increasing the number of students with an awareness of engineering is one way to potentially increase the diversity of engineers. We argue that this necessitates the need to provide awareness via proximal, supportive, influences other than family members. Researching proximal environmental influences at a student's high school may enable our team to better understand why students with similar academic course experiences from different high schools have a different rate of transfer into engineering programs. Importantly, unraveling the specificity of differences through qualitative interviews of potential influencers ("gatekeepers") could help educators consider uniquely designed interventions for their schools to increase awareness of engineering careers.

As we continue to gather data within this and other case sites, we note a limitation in our current data. Despite having asked our participants about their beliefs about what influences students' choices towards or away from engineering, the responses sometimes encompassed multiple possible career pathways within a single response making it difficult to parse out engineering specific aspects of the response. At the same time, we recognize that engineering is a sub-set of 4-year pathways and therefore, beliefs about what influences four-year pathways would be relevant to engineering as well.

Interviews with principals as well as teachers and county school administrators will continue as we progress through phase two of the project. These preliminary findings will inform iterations of our interview protocol as needed, and the insights gained will be incorporated into future analyses.

Acknowledgements

This research is funded by the National Science Foundation (NSF) as a research grant (NSF-EEC-1647928) and does not necessarily reflect the views of the National Science Foundation.

References

Boynton, M. (2014). *People not print: Exploring engineering future possible self development in rural areas of tennessee's cumberland plateau.* (PhD Dissertation), Virginia Tech.

Carrico, C., Matusovich, H. M., & Paretti, M. C. (2017). A qualitative analysis of career choice pathways of college-oriented rural central Appalachian high school students. *Journal of Career Development*. doi:10.1177/0894845317725603

Carrico, C., Murzi, H., & Matusovich, H. (2016). *The roles of socializers in career choice decisions for high school students in rural central appalachia: "Who's doing what?"* Paper presented at the 2016 IEEE Frontiers in Education Conference (FIE). Erie, PA.

Dick, T. P., & Rallis, S. F. (1991). Factors and influences on high school students' career choices. *Journal of Research in Mathematics Education, 22*(4), 281 - 292.

Garriott, P. O., Raque-Bogdan, T. L., Zoma, L., Mackie-Hernandez, D., & Lavin, K. (2016). Social cognitive predictors of Mexican American high school students' math/science career goals. *Journal of Career Development, 44*, 77-90. doi:10.1177/0894845316633860

Gillen, A. L., Kinoshita, T., Knight, D., Grohs, J., Carrico, C., Matusovich, H. M., … Bradburn, I. (2017). *WIP: Gatekeepers to broadening participation in engineering: Investigating variation across high schools comparing who could go versus who does go into engineering*. Paper presented at the 2017 IEEE Frontiers in Education Conference. Indianapolis, ID.

Grauer, S. (2012). How big is a small school?: A review of the literature on absolute secondary school size. Retrieved from http://smallschoolscoalition.com/wp-content/uploads/2012/01/How-Big-is-a-SMALL-SCHOOL. pdf

Kim, M. S., & Seo, Y. S. (2014). Social cognitive predictors of academic interests and goals in South Korean engineering students. *Journal of Career Development, 41*(6), 526-546. doi:10.1177/0894845313519703

Lent, R. W., & Brown, S. D. (1996). Social cognitive approach to career development: An overview. *The Career Development Quarterly*, *44*(4), 310–321. https://doi.org/10.1002/j.2161-0045.1996.tb00448.x

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, *45*(1), 79–122. https://doi.org/10.1006/jvbe.1994.1027

Lent, R. W., Brown, S. D., & Hackett, G. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. *Journal of Counseling Psychology,47* (1), 36-49. doi:10.1037/0022-0167.47.1.36

Martin, J. P., Simmons, D. R., & Yu, S. L. (2014). Family roles in engineering undergraduates' academic and career choices: Does parental educational attainment matter? *International Journal of Engineering Education, 30*(1), 136-149.

Matusovich, H. M., Carrico, C., Paretti, M. C., & Boynton, M. (2017). Engineering as a career choice in rural Appalachia: Sparking and sustaining interest. International *Journal of Engineering Education, 33*(1), 1-13.

Matusovich, H. M., Streveler, R. A., Miller, R. L., & Olds, B. (2009). *I'm Graduating This Year! So What is an Engineer Anyway?* Paper presented at the American Society for Engineering Education Annual Conference and Exposition. Austin, TX.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2013). *Qualitative data analysis: A methods sourcebook* (3rd edition). Thousand Oaks, California: SAGE Publications, Inc.

Schreuders, P. D., & Mannon, S. E. (2007). All in the (engineering) family? - the family occupational background of men and women engineering students. *Journal of Women and Minorities in Science and Engineering,13*(4), 333-351. doi:10.1615/JWomenMinorScienEng.v13.i4.20

Simmons, D. R., & Martin, J. P. (2014). Developing effective engineering fictive kin to support undergraduate first-generation college students. *Journal of Women and Minorities in Science and Engineering, 20*(3), 279-292. doi:10.1615/JWomenMinorScienEng.2014010979

Turley, R. N. L. (2009). College proximity: Mapping access to opportunity. *Sociology of Education*, *82*(2), 126–146.

U.S. Census. (2016). U.S. Census Bureau, American Community Survey. Retrieved from https://www.census.gov/quickfacts/geo/chart/

Virginia Department of Education. (2017). Program Statistics and Reports. Retrieved from http://www.doe.virginia.gov/support/nutrition/statistics/index.shtml

Yin, R. K. (2003). *Case study research: design and methods* (3rd ed). Thousand Oaks, Calif: Sage Publications.