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Chasing the Holy Grail: Pushing the Academic Persistence of Highly Motivated, Underprepared URM Students Pursuing Engineering

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Chasing the Holy Grail: Pushing the Academic Persistence and Retention of Highly Motivated, Mathematically Underprepared Minority Engineering Students

Abstract

This paper presents quantitative and qualitative data to examine motivation to persist amongst African American and Hispanic/Latino undergraduate engineering students. Psychological factors including "grit", self-determination and social cognitive career theories are used to explore self-efficacy, goal orientation and perception of institutional culture as mediators of academic achievement. A significant part of this paper analyzes responses to interventions designed to support retention of students lacking the math background to "hit the ground running" upon entering a large, public predominantly white institution (PWI)'s college of engineering, with a disproportionate number of minorities in the underprepared category. Targeted retention interventions for first year students yielded statistically significant improvement in math course progression, particularly for minority students. Overall attrition decreased by 10% in two successive years. Recent research suggests positive student outcomes can be achieved by transforming institutional culture to ensure minority student success. A preliminary within group comparison of minority engineering undergraduates (N=50) at two campuses - a PWI and a Historically Black College and University/Minority Serving Institution (HBCU/MSI) indicated 75% were satisfied with their choice of institution. However interesting differences emerged regarding perceived marketability of their engineering degree (higher at PWI), perceived welcome at the institution of choice (higher at HBCU/MSI), and perception of opportunities to network with faculty to conduct research (higher at HBCU/MSI). It is anticipated these culturally aligned findings will contribute to efforts to identify and adopt the individual, college and university level practices most likely to support minority engineering persistence.

Context & Background

National leadership and STEM outreach to produce talent for the knowledge economy are at the highest levels, with the President of the United States championing STEM education in eight consecutive "State of the Union" addresses (2008-2016). The result has been an important resurgence in awareness of STEM careers, particularly in engineering, as reflected in the quadrupling of size of a large public university's College of Engineering the past 10 years.

However in spite of the growth, the college's struggle to graduate more engineers mirrors longstanding challenges to reduce attrition, retain and graduate students of all backgrounds, ethnicities and genders. Efforts to ensure student progression in the degree are highly dependent on academic achievement. It is well documented that American cultural and linguistic minorities (African American, Hispanic/Latino, and Native American) receive less rigorous preparation in high school (Figueroa, Hurtado &

Wilkins, 2015), exacerbated by continued erosion of math numeracy in K-12 education in general.

The primary question this paper answers is the extent to which student determination to succeed successfully mitigates an academic disadvantage when bolstered by institutional investment in cognitive (learning) and non-cognitive (supplemental curricular) support. Exploring relationships between students' psychological and personality profiles (confidence and goal orientation), and the contextual environments they navigate can offer rich feedback on achieving a specific career goal (Lent, Brown and Hackett, 2000).

This paper suggests that math remediation is critical, but must be done in an institutional context that successfully leverages student determination to succeed. Results in this paper are based on efforts to support underrepresented student retention at a predominantly white engineering institution (PWI). Prior to beginning this analysis, the estimated cumulative attrition rates were such that for every 100 students who started in Engineering, about 75% were retained after the first year, and 45% after the second year. In total, due to a variety of reasons including financial burden, only 18% were obtaining baccalaureate degrees in four years. In comparison to the rest of the university, the freshman retention rate across the university is approximately 89%, and on-time (e.g. four year) graduation rates have ranged between 38-67% depending on the program.

The traditional faculty argument that "admitting poorly prepared students" is the reason for dramatic attrition has diminished given increasingly competitive university admissions. For the period 2011-2013, quantitative data was available for N=1,484 students and retrospective analysis for ethnicity and math placement yielded 11.9% who identified as African American, 2.5% who identified as Hispanic. While differences in gender yielded no discernible differences in math placement, SAT math scores and GPA in initial math course, incoming African American and Hispanic engineering students had significantly lower SAT scores than their white and Asian counterparts, but were still *above the national average for that period* (engineering admission SAT-M=566, minority engineering SAT-M=543 vs. national average SAT-M=514).

However, SAT math scores were not reflected in actual math placement, and 42% of all incoming engineering students were placed below Calculus I, at least one semester behind their higher placed peers and in many cases, at least full one year behind. Incoming minority engineering students were most likely to be placed in lower level math courses, delaying progression in the degree. Thus, the decision to invest in retention reflected the disconnect between a nationally standardized test, the university's math placement tests and the socio-emotional dissonance minority students experienced when advised attaining an engineering degree would take longer (and cost more) than originally expected.

As a result, the engineering college elected to better support "high potential" but "mathematically underprepared" students by implementing cognitive and non-cognitive interventions this paper will present. It is hoped that the results will benefit other

engineering colleges seeking to improve minority student outcomes using evidence-based measures.

Methodology

There is clearly an opportunity for education researchers to quantify not only "what works" but "why" for retaining underrepresented groups (URGs) in rigorous fields of study. In general changes to pedagogy and curriculum have not yielded an increase in the number or diversity of students entering the quantitative disciplines (Jolly et al, 2004).

Using the 2011-2013 data as a baseline, the decision was made to help underprepared engineering students improve their math achievement outcomes by modifying the curriculum to test an applied mathematics course for engineers adapted from Wright State University's NSF funded ENG101 applied math course. Freshmen and transfer students (N=507) entering in Fall 2014 and Fall 2015 included 84% freshmen, 16% transfers, 21% women, and 14% ethnic minorities. While 86% of students reported very strong self-efficacy (belief) in their ability to study engineering, the reality is that half tested below Calculus I, 66%% had no engineering coursework in high school, only 32% had a family member in the field, and only 5% had ever had an industry mentor to introduce them to the profession.

These descriptive statistics are at odds with established predictors of engineering persistence, including likelihood of having a family member or parent in the discipline, participation in pre-college engineering activities, and ability to build on prior knowledge and identity (Byers, et al 2010), particularly through peer mentoring (Good, Halpin & Halpin, 2002). Given the majority of engineers in the US are predominately white males, it is generally understood that minority undergraduates who do not have those favorable experiences may face challenges with the coursework and navigating the culture of engineering institutions.

This is critically important given the fact that colleges of engineering are professional schools with operating cultures that are traditionally rigid with very prescriptive pathways to attain the degree. This study posits that the integration of cognitive and non-cognitive factors can most effectively quantify what works for retaining more diverse engineering students in the first two years. Of particular interest are the following overarching questions:

(1) How would a cognitive intervention (engineering math remediation) impact underrepresented students' progression in the degree?
(2) Are there **non-cognitive** traits minority students demonstrate that support their engagement, identification with and persistence in engineering?
(3) What factors contributed to **changes in motivation** to persist for minority engineering students based on the type of institution selected?

Student self-report surveys yielded qualitative data on perceived college culture, learning context, cognitive support and student engagement for two successive years of freshmen (14% minority) students who matriculated into a large, northeast public university's College of Engineering in Fall 2014 and Fall 2015. Data was collected upon entry the first week of class, and at the end of each semester. Analysis of quantitative data was used to map successful cognitive (math) progression to non-cognitive attributes like self-determination, grit and motivational drivers for minority students. Because the College had limited available retention data from which to begin this project, the retrospective baseline for the study was established using descriptive and regression analysis first-year engineering students (N=1,484) who entered the college in Fall 2011, 2012 and 2013.

In examining the available student data, the attrition rate for first-year students in the College averaged 25%, with an additional 25-30% leaving engineering by their sophomore year. In the following chart, SAT Math scores correlated to results on university math placement exams, yielding the following results for three possible starting points in the engineering degree program:

- Entry-level college math (MATH 0701, MATH 0702 and MATH 1015)
- Pre-Calculus (MATH 1021, MATH 1022, and MATH 1031)
- Calculus I (MATH 1041)

Using math placement as a predictor of time to completion, students who placed into entry-level or pre-calculus were most likely to face a five-six year graduation timeline and increased student debt. In the chart below, math placement is correlated to the average SATs of students placed in that course.

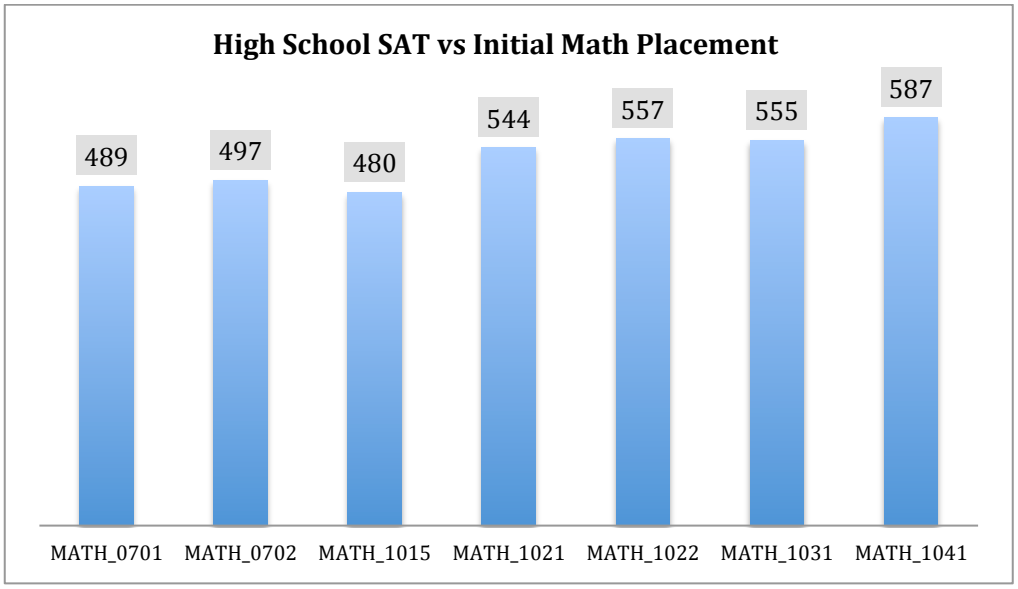

Chart 1: Incoming Freshman SAT versus Initial Assigned Math Course (2011-2013)

Recall again that African American and Hispanic engineering students had significantly lower SAT scores than their white and Asian counterparts, but were still *above the national average for that period* (engineering admission SAT-M=566, minority engineering SAT-M=543 vs. national average SAT-M=514). It is also important to note that, *higher SATs did not necessarily correlate to higher GPA* for first year engineering students, and in fact, regardless of incoming SAT scores, freshmen and transfer students who placed in the bottom quartile were identified as "at risk" for leaving engineering due to math. Compared to their admission numbers, a disproportionate percentage of underrepresented students required math remediation to move back on track with Calculus I (29.6% Black/African-American, 17.6% female and 3.7% Hispanic).

Armed with statistical baselines, the next step was to review engineering education literature to find evidence-based practices. Recent studies consistently tied persistence to academic support (remediation, tutoring, supplemental instruction), operational culture (faculty engagement, mentoring, research opportunities) and institutional context (type, academic support, investment in retention) (Figueroa, et al 2015; Hughes, et al 2013). The following approaches were launched to improve retention in general. No explicit goals were set to improve minority student progress, it was presumed a general approach would benefit all.

- Faculty Engagement. A summer 2014 faculty retreat was held to elicit feedback on proposed retention strategies given the incoming Fall 2014 math placement results;
- Math. A math intervention course was adapted from Wright State University's NSF-funded EGR101 engineering applied math course and implemented in Fall 2014, Spring 2015 and Fall 2015; and
- Student Engagement. Leaders of minority-led engineering organizations at the PWI and HBCU helped develop, refine and distribute a survey on minority engineering persistence for this paper.

In summer 2014, tenured and non-tenure track engineering faculty were presented with the 2011-2013 retrospective data. They were also provided an overview of the university's new 4-year graduation mandate, given the math profiles of incoming freshmen and asked to respond to proposed measures to support retention. Not surprisingly, most ignored the incongruence between SATs and college math placement results and called on the Dean to demand an increase in SATs to ensure better quality students. The general consensus was that retention efforts would have limited success, although a few intrepid members formed an ad hoc retention group to better understand the issues.

Against that backdrop, the second intervention focused on cognitive development. Carefully worded invitations were sent from the Dean to at risk students encouraging them as "future engineers" to take advantage of a new engineering math course designed to get them back on track toward earning the degree. Students were offered the applied mathematics course, supplemental instruction (tutoring and recitations), and labs to

deepen conceptual understanding. A total of 88 students voluntarily participated, reflecting the following demographics:

Descriptive Statistics	**Fall 2014 (N=46) ENG 1102**	**Spring 2015 (N=14) ENG 1102**	**Fall 2015 (N=27) ENG 1103**
Males	84%	84%	79%
Females	16%	16%	21%
Freshman	98%	0%	93%
Transfer	2%	100%	7%
White	68%	42%	50%
African-Am	14%	50%	25%
Asian	11%	8%	11%
Hispanic-Latino	7%	-	4%
Native Am/PI	-	-	-
Initial Math Course:			
Calculus I	22%	25%	22%
Pre-Calculus	37%	58%	64%
College Algebra or below	31%	17%	14%

Table 1. Demographic profile of students enrolled in engineering math remediation course by semester.

The college piloted the NSF funded Wright State EGR101 engineering math course modified to include instructors from different engineering disciplines, discipline specific labs and eliminated MATLAB. The Wright State model used a single instructor, labs were aligned to general engineering and MATLAB was required.

In spite of the modifications, statistical analysis revealed that students who tested into entry-level math courses (algebra to pre-calculus), and took the ENGR1102/1103 course *concurrent* with their math class, achieved a statistically significant improvement between pre- and post-test, with an effect size considered large (t=2.56, $\eta_p^2 = .138$). Their improved performance in math *after* taking ENG1102/3 (t=.342*, p=.079) is close to being statistically significant (p<.05), disproportionately benefiting the larger percentage of minority students enrolled in each cohort of the course.

A reasonable conclusion is that ENG1102 offered earlier in the math sequence helped bolster student performance across all math profiles, but particularly for minority students, giving them more practice time building foundational math skills and moving them forward in the degree without insulting their lack of prior knowledge. The access to supplemental instruction and co-curricular activities deepened understanding of engineering disciplines and seem to have mediated the lack of knowledge students exhibited on first matriculating into engineering.

The third intervention was the intentional outreach to minority student leaders in engineering to develop culturally responsive strategies at the college level for retaining minority engineering students beyond the second year. The administration's shift to a more student-centric orientation reflected national efforts to better understanding the non-cognitive factors that contribute to a culture of high performance and student retention.

Non-cognitive Theoretical Models

Understanding the intersection between early engineering students' self-confidence, determination and career goals is fundamental to improve their academic persistence and retention. The approach outlined in this paper used Social Cognitive Career Theory (Lent, Brown, & Hackett 1994; 2000), which allows education researchers to explore relationships between an individual's confidence and goal orientation, and the contextual choices they make to achieve a specific career (2000).

Recent STEM research using social cognitive career theory as the framework suggests institutional culture and context can have tremendous impact on STEM identity formation and cognitive persistence for all students, particularly underrepresented groups (Byars-Winston, 2014). Within SCCT, there are three key constructs that influence career development: *self-efficacy* (confidence based on past performance and personal accomplishments), *outcome expectation* (belief that hard work will be rewarded) and *personal goals* (level of determination and drive to achieve a specific goal).

Self- determination theory (SDT) is another plausible framework for explaining how students' psychological feelings of independence, control, competence and belonging helped them respond to extrinsic elements of their environment with improved achievement and persistence (Deci & Ryan, 2000; Ryan & Deci, 2000). Stated differently, how and to what extent college culture supports or undermines students' goals either increases or decreases student efforts toward achieving a difficult goal.

This study evaluates changes in the engineering college's institutional culture and the measurable impact on minority student aspirations and motivations to overcome incoming academic shortfalls. One metric gaining traction is the concept that student persistence is a function of "grit" defined by Duckworth and colleagues (2007) as "perseverance and passion for long-term goals. Grit entails working strenuously toward challenges, maintaining effort and interest over years despite failure, adversity, and plateaus in progress" (p. 1087-1088).

In addition to grit, self-discipline is of interest. Duckworth and Seligman (2005) suggest that the reason students do not perform to their intellectual potential is their "failure to exercise self-discipline" (p.944). In other words self-discipline has a greater impact on academic performance and long-term success than raw intellectual talent on every measure of academic achievement than IQ (2005). In 2013, the U.S. Department of Education released a report entitled "*Promoting Grit, Tenacity, and Perseverance: Critical factors for success in the 21st century*." However, only a few relatively small studies have begun to look at non-cognitive traits like grit and self-discipline in STEM fields specifically (e.g. Gibbs & Griffin, 2013).

The current study explores the self-discipline and grit of engineering students in general, with a supplemental analysis of the perception of minority students that their engineering

college's retention efforts supported the above average determination to become engineers.

Establishing Student Motivational Baselines for Engineering

In Fall 2014 and Fall 2015 the same cohorts of incoming engineering students (N=507) were asked to complete an engineering interest survey, and a 12-item "grit" survey the first week of class (Duckworth, et al, 2007, p.1087-1101). The grit survey used a bi-directional five-point scale such that items 1, 4, 6, 9, 10 and 12 were rated with decreasing intensity from *5=very much like me* to *1=not like me at all*, while items 2, 3, 5, 7, 8 and 11 were rated with increasing intensity from *1=very much like me* to *5=not like me at all.*

GRIT & PERSEVERENCE ITEMS	2014 N=280	Std Dev, σ	2015 N=229	Std Dev, σ
I have overcome setbacks to conquer an important challenge	3.97	0.26	4.05	0.31
New ideas and projects sometimes distract me from previous ones	3.08	0.31	3.02	0.31
My interests change from year to year	3.47	0.35	3.39	0.4
Setbacks don't discourage me	3.73	1.4	3.52	0.31
I was obsessed with a certain idea or project for a short time but lost interest	3.46	0.53	3.37	0.56
I am a hard worker	4.37	1.78	4.37	0.81
I often set a goal but later choose to pursue a different one	3.61	0.24	3.56	0.26
I have diffculty maintaining focus on projects that take more than a few months to complete	3.62	0.48	3.62	0.51
I finish whatever I begin	4	0.14	4.05	0.11
I have completed a goal that took years of work	3.71	1.88	3.71	0.05
I become interested in new pursuits every few months	2.86	0.94	2.82	0.97
I am diligent	4.19	2.66	4.2	0.4
Overall "Grit" Profile by Cohort	**3.68**	**0.43**	**3.64**	**0.47**

Table 2. Survey of grit of convenience sample of N=509 1st year freshman and transfer engineering students.

The nearly identical self-reports across the two cohorts confirmed that similar student personality profiles had applied to and were admitted to the college of engineering. The "grit" profiles for each cohort exceeded 3.0 (2014 – 3.68, SD 0.43; 2015 – 3.64, SD 0.47).

Student surveys for Fall 2014 and Fall 2015 cohort also yielded qualitative data on the initial perceptions, motivations and career expectations of future engineers across ethnicity and gender (N=507). Based on this data, the highest percentage of students were influenced by their parents to study engineering but very few actually had access to pre-college engineering programs and only 5% had ever had an industry mentor. It seems apparent that knowing that engineering is as a professional degree (and what that means

compared to other programs of study) would be beneficial to helping students make fully informed decisions before embarking on a rigorous and costly college program. The chart below depicts the strongest pre-college engineering influences incoming students identified.

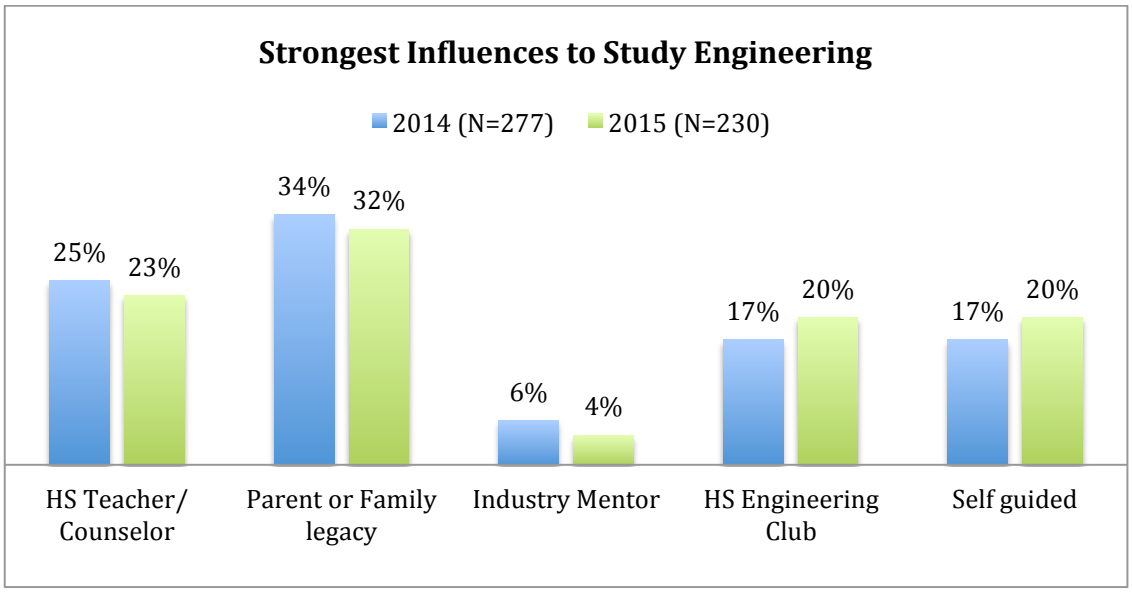

Chart 2: Key influencers on 1st year engineering students' decision to pursue the degree.

Because American engineering fields have been historically white male dominated, it is reasonable to assume that minority families have had fewer opportunities to transfer a legacy of engineering knowledge and culture. It is also reasonable to presume that white and Asian dominated engineering faculty in predominately white institutions would have little day-to-day experience tapping the motivational drivers of minority students to encourage persistence.

This is an important point as minority students are culturally predisposed to strong interaction between elders and youth, translated to higher reliance and expectation of quality interaction with adult mentors (Boykin, 2006; Hurley, et al 2005; Delpit, 1988). The cultural dissonance marginalized students experience in any education setting is rarely discussed as a measurable construct that can be leveraged through creative internships, mentoring and research opportunities with faculty. Clearly academic remediation is a critical factor for underprepared students, but at the macro level the engineering learning environment offers ripe opportunities for recasting engineering students as customers and meeting their transitional needs.

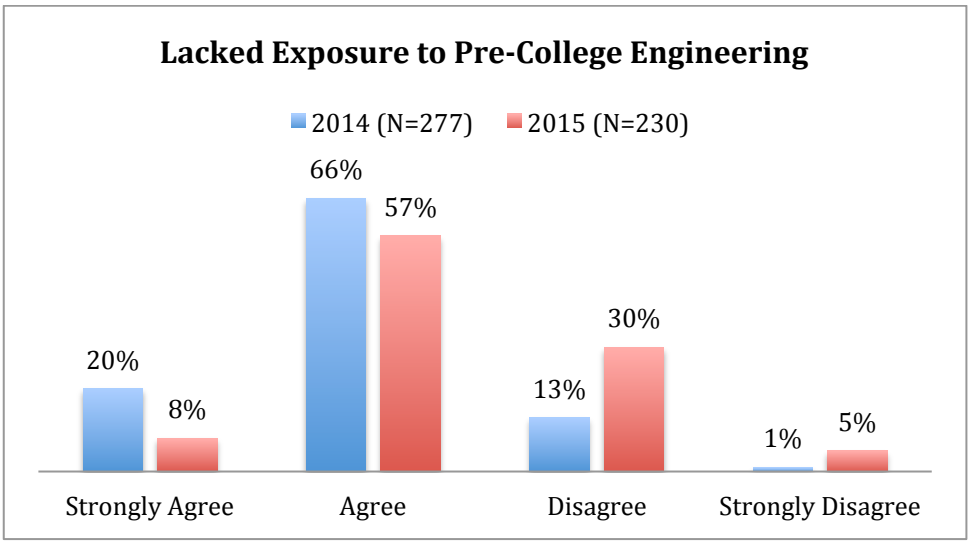

Chart 3: Incoming 1st year students' access to pre-college engineering programs and/or information.

The traditional pools of domestic white male talent continue to show strong interest in engineering, but are declining in number. Changing American demographics reflect 50+million Baby Boomers eligible to retire, a workforce that is nearly 50% women, and rising numbers of underrepresented minorities who may not have the same inherited legacy in engineering but still consider it realistic and attainable.

In addition to exposure, students' motivation to study engineering is captured in the chart below, with the vast majority of students *intrinsically motivated* to design, build and improve things versus *extrinsically motivated* by making money or gaining recognition. These future engineers want to do good things with their expertise.

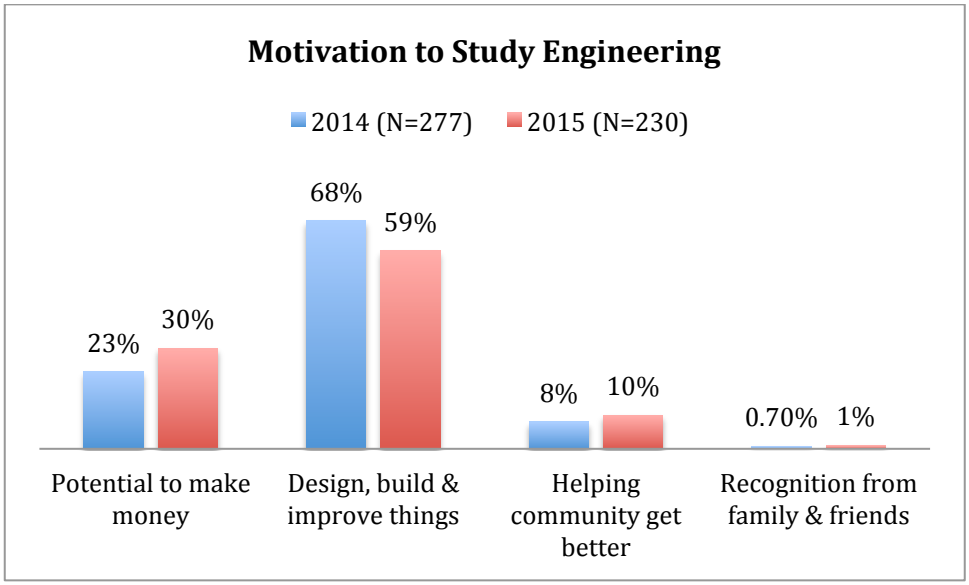

Chart 4: Incoming 1st year students' motivation to study engineering

Their desire was supported by their self-confidence and belief, regardless of socio-economic background, that they were sufficiently prepared in high school math and science courses to tackle the same courses in their college degree.

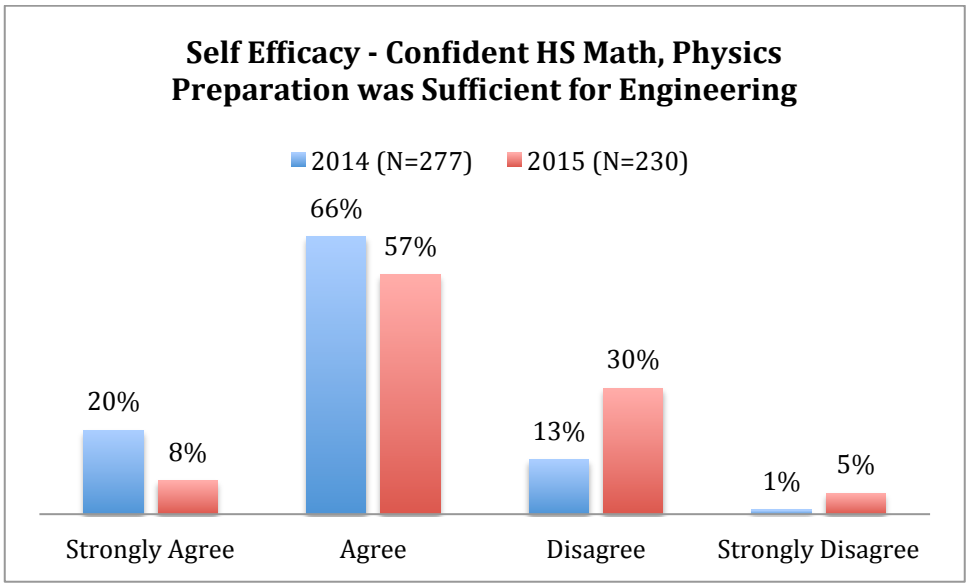

Chart 5: Incoming 1st year students' confidence in high school preparation.

For the 60% of incoming Fall 2014 and roughly 40% of Fall 2015 first year engineering students who tested below Calculus I and were considered mathematically underprepared, emerging evidence from this study suggests those students will persist as long as it is clear the appropriate cognitive and contextual supports are provided.

Minority Student Perception of Engineering College Context

As a follow on study to better understand the motivations of minority students studying engineering, a within group analysis was conceived to further explore how minority undergraduate students' navigate the social and institutional contexts they experience while pursuing engineering. A convenience sample of undergraduate minority students of African and Hispanic descent have been asked by their peers to respond to a Spring 2016 survey. While this study does not presume that diversity was a primary factor for students choosing a college, it does not ignore that possibility.

A 22-item student questionnaire was developed by the lead author and two minority engineering student leaders – one enrolled at the predominantly white institution (PWI) featured in this paper, and one attending a historically black engineering college (HBCU) in the northeast United States. Self-determination theory and its relation to independence, control and sense of belonging was shared with both students and helped guide the questions they wanted to ask their peers. Responses were based on a five-item Likert scale, strongly agree, agree, neutral/not sure, disagree and strongly disagree.

Thus far 50 freshmen and transfer students have responded, 55% attending the PWI, 45% attending the HBCU; 72% males, 28% females; 84% African American, 14% African/Caribbean, 2% South American and 8% international students of color. Nearly 50% of the women of color in this survey reported identifying by race/ethnicity over gender and 47% of respondents selected engineering without guidance compared to 28% who chose engineering without guidance and 25% who were undeclared.

Internal/External Motivators and Drivers

The responses (N=50) confirm the previous data that engineering students have strong self-efficacy, self-determination and grit. The following table displays responses to the question "*As a student of color how have internal or external factors motivated you?*

Student motivations	**Strongly Agree/Agree**	**Neutral/ Not Sure**	**Disagree/Strongly Disagree**
I have the inner drive to achieve my goals	97%	3%	0%
Doing well represents my family's hard work	85%	10%	5%
I won't let white society stereotype or limit me	87%%	10%	3%
I am diligent and will finish what I start	90%	10%	0%
I believe I will be rewarded for my hard work	92%	5%	3%

Table 3: Comparison of minority engineering undergraduates' intrinsic and extrinsic motivations.

This emerging data contributes to better understanding how to incoporate "positive psychology" into retention strategies to better support minority engineering students. Although 50% of the respondents agreed their high school math and science was not as strong as they thought, 85% disagreed that they "just didn't like it". Their strong self discipline and ambition, in spite of being disproportionately underprepared in math, may be an important explanatory factor for helping engineering colleges evolve to support the aspirations of engineering students willing to work through initial challenges and atypical profiles.

The top five responses to the question "*Did these factors help you persist in your engineering degree*?" in Table 4 reinforce that minority engineering students' personal motivation (self and family) should be reflected and respected in retention strategies that yield more minority engineering graduates.

	Strongly Agree/Agree	**Neutral/ Not Sure**	**Disagree/Strongly Disagree**
Self Discipline	90%	5%	5%

Family Encouragement	85%	10%	5%
College Climate	70%	15%	15%
Faculty Interaction	66%	19%	14%
Organizations (NSBE/SHPE)	65%	20%	15%
Financial Aid	62%	18%	20%

Table 4: Identified factors that contribute to minority engineering persistence.

Students who responded well to the ENG1102/1103 math intervention, a disproportionate number of them minority students underprepared for engineering in high school, rated the climate of the college, experienced during orientations, interactions with engineering faculty and their participation in student engineering organizations like the National Society for Black Engineers (NSBE) and the Society of Hispanic Professional Engineers (SHPE), as important "non-cognitive" factors that contributed to their persistence.

Understanding the importance of student organizations is helpful as it appears they assume the best practice role research suggests should rest with engaged faculty (. Minority-led engineering organizations position themselves as the bridge for new peers, offering the "climate" support traditional PWI cultures may not have the capacity to create. For example, when asked "*How did these factors impact your persistence*", there was very strong agreement across campus type that NSBE and SHPE fostered a sense of identity (65%), provided critical academic support (78%), fostered a sense of belonging (81%) and provided opportunities to network for research and internships inside and outside the college setting (84%).

In comparing the selection criteria minority engineering used to select the type of institution they entered, the following table offers interesting insights:

	PWI **(N=26)**	**HBCU** **(N=24)**
Affordability	69%	68%
Marketability of engineering degree after graduation	67%	62%
"On boarding" experience	63%	67%
Faculty networking & research opportunities	60%	70%
Course Rigor	49%	50%

Table 5: Identified institutional contextual factors that contribute to minority engineering persistence.

Minority engineering students who selected the HBCU mirrored their peers at the PWI in seeking affordable, rigorous degrees. An interesting finding is in the higher expectation of access to opportunities for research at the HBCU even though the marketability of the engineering degree from the PWI is perceived to be higher. The quality of the welcome received is also worth analyzing to determine if existing engineering students, faculty or administration were involved in "onboarding" new students.

Women of color pursuing engineering degrees were fairly consistent with their male counterparts until asked to respond to the quality of their interaction with other women in engineering. Responses (N=15) confirmed that while expectations for success were high (86%), more than half (53%) were neutral or disagreed they'd had positive experiences with white and Asian women and faculty and peers. Again, there are significant opportunities to further study institutional climate to ensure progression for every subcategory of underrepresented group. Those engineering colleges willing to make modest adjustments to tap into those cultural similarities may yield higher production of diverse talent than initially thought when considering academic profiles alone.

Minority engineering students across both institutional contexts display strong self-discipline and grit and believe they have the self-discipline to succeed. They also report cultures of high family expectation and encouragement to the extent that congruence between family culture and positive college context appear to be explanatory factors in students' persistence in engineering. The powerful impact of congruent family and institutional culture on persistence cannot be overstated.

Additional data will be collected to further explore the impact of institutional culture on producing diverse engineering talent. In the short term, the degree of self confidence intrepid minority students demonstrate in choosing a "really hard" career, the strength of their outcome expectations and their commitment to their personal goals are consistent with Social Cognitive Career Theory that suggests these non-cognitive, psycho-social orientations may be equal in importance to academic supports for disadvantaged students pursuing the engineering degree. To the extent the cognitive support is provided in a college climate that respects self-determination and grit, there is a strong likelihood more minority engineers can be produced.

Student Outcome Implications

The primary study in this paper demonstrated a successful 10% decrease in 1st year engineering attrition for both Fall 2014 and Fall 2015 and confirmed that above average grit across gender and ethnicity. Those characteristics appear to have mediated being mathematically underprepared among diverse engineering students, and combined with cognitive and non-cognitive supports may provide a framework for helping colleges invest in culturally responsive interventions to retain high potential minority students in their quest to become engineers.

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