The Influence Parent Socialization and School Environment has on African-American Adolescent Males' Mathematics Self-Efficacy and Engineering Career Trajectory

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Abstract— **This Full Paper in the Research Category presents a study aimed at examining the moderating/mediating role of parental academic socialization messages and school resources on African-American males' engineering career trajectory and self-efficacy beliefs. With men being overrepresented in engineering fields, the dramatically lower representation of African-American men (AFAM) looks especially conspicuous. The underrepresentation is a concern for diversity and socio-economic status of the AFAM community and the roots need to be understood. Classical theories explain how career choice is influenced by motivation and socialization, so examining how mathematics self-efficacy and socialization combine to inform career choice of AFAM male adolescents can help to understand their participation in the pipeline to engineering jobs. This study uses data from the nationally represented Educational Longitudinal Study analyzed using multi-level logistic and longitudinal models. Findings suggest that parents who expect school success, believe people can learn to be good at math, and check homework are related to increased odds that their child will be on an engineering career trajectory. Parents who more frequently helped with their child's homework decreased their child's odds of being on an engineering career trajectory. This study contributes to existing literature on increasing the engineering pipeline for underrepresented minorities.**

Keywords—mathematics socialization, adolescents, engineering, STEM, pipeline, African-American, Black, males

I. Introduction

Diversifying the science, technology, engineering and mathematics (STEM) workforce has been an important issue in the United States since before the turn of the 21st century. While efforts have been made in recent decades to increase participation of minority groups, there have been only minor changes in STEM workforce diversity [1]. Unfortunately, the STEM workforce is mostly homogeneous and does not reflect the demographics of America, which has an African-American population of 13.2% but only represent 4% of engineering bachelor's degree recipients, 3.6% of the engineering workforce, and 2.6% of engineering faculty [2]. With engineering fields being traditionally dominated by men, but containing a dearth of African-Americans, the need to provide more African-American men in the STEM workforce is more than just a concern for diversity. The African-American community can benefit from greater representation in jobs that pay higher than the national average salary [3]. In the U.S., 39 percent of African-American children and adolescents are living in poverty, which is more than double the 14 percent poverty rate for non-Latino, White, and Asian children and adolescents. Multi-dimensional poverty, or poverty manifested in alternate forms such as poor health, inadequate housing, and poor-quality education, is more likely experienced by minority groups [4]. Increased participation in STEM careers can have an impact on African-American families' overall socioeconomic status in the U.S.

II. Theory

Many studies in the STEM field have centered around motivation for learning mathematics and an individual's perception of their ability to do math, or math self-efficacy [5-8]. In this study, the focus will move beyond the internal factors affecting the abilities of these students and instead place emphasis on how individuals manage the external factors of parental socialization and available school facilities while making decisions that affect their career trajectory. When students hear statements like, "I was never good at math" from their parents, how does it affect their belief in their own capabilities? Children and youth are socialized in many ways; siblings, friends, and fictive kin are a few examples, but this study focuses on the parents as primary socializers in the lives of their children and it is uncontested in the literature that parents are important agents in providing opportunities, support, and resources to their children [7, 9-14].

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The expectancy-value theoretical framework demonstrates how self-efficacy is affected by a socializer's beliefs and behavior and how the socialization messages that parents exhibit influences career choices [8]. Career choice, or for the purposes of this study, career path, is informed by socialization and self-efficacy, as well as Social Cognitive Career Theory (SCCT) which explains how particular ecological structures facilitate or impede individuals' career choice behavior [15]. Reference [16] used a combination of expectancy-value theory and social-cognitive career theory to examine how social support influenced self-efficacy in a longitutidanal study from 5th grade to early college. Students perceived greater support, in the form of encouragement, high expectations, and placing high value on studying math and science, in the 5th grade and in college more than they did in middle and high school. The lack of perceived support during middle and high school is important to note, since important career trajectory decisions are made at those junctures. By focusing on high school in this study, the aim is to discover details about the impact that parents and schools have on AFAM as they make academic and career choices.

The Garcia Coll ecological model is used to explain how inhibiting and promoting environments directly influence the adaptive cultures that are created in response to minority children's and families' experience within these environments [17]. The integrative model has eight (8) constructs including, but not limited to, how social status, racism, oppression, discrimination and racial socialization interacts with the environment, that is, culture, family, and the self, to create adaptive competencies, cognitive, social, emotional skills. These lead to student decisions being made about their career goals.

Crenshaw's Intersectionality Theory explains how race and gender intersect as students are socialized by parents and schools [18]. African-American males have the task of navigating as students within the school and home context, processing parent socialization messages, and maintaining sufficient self-efficacy to develop the cognitive skills necessary for assisting them to make career choices when outside pressures exist related to simply being in a minority group, and a minority within STEM fields. In this study, I posit that parents' math socialization combined with a child's school environment can influence African-American adolescent male students' self-efficacy beliefs and effect engineering career trajectory.

III. Hypotheses

The terms "pipeline," "school" and "African-American" are becoming increasingly negatively associated with the school-to-prison pipeline. This study aims to add to the discussion and to generate and emphasize the STEM pipeline for African-American male students. By recognizing the important role that math self-efficacy plays in the engineering career trajectory, I posit the following hypotheses to be tested in this study:

1. Career engineering trajectory is mediated by parents' math socialization and/or school environment.
2. Career engineering trajectory is moderated by parents' math socialization and/or school environment.
3. Parent socialization messages are affected by the school environment.
4. The intersection of an adolescents' race and gender effects the socialization messages received by parents.
5. Socialization messages influences African-American males' career trajectory.
6. School environment has as effect on African-American males' career trajectory.

IV. Data

The data used is this study are drawn from the restricted Educational Longitudinal Study of 2002 (ELS:2002), which is a nationally representative study of 10th graders in 2002 and 12th graders in 2004 from public, private, and charter schools in the U.S. The ELS:2002 study was conducted by the U.S. Department of Education with foci of 1) students' trajectories from the beginning of high school into postsecondary education, the workforce, and 2) the different patterns of college access and persistence that occur in the years following high school completion. All measures offered in the ELS have established and acceptable levels of reliability [19].

Three rounds of the data are analyzed; the base year survey of 10th graders in 2002, including surveys from parents and administrators, a follow-up of 12th graders in 2004 and another follow-up in 2005 after graduation. The full sample consists of 16,200 students with 750 schools, but this analysis is reduced to the 6,580 participants with complete responses for the variables used in this study. The data are weighted using a weights developed by the data distributors to compensate for uneven probabilities of being selected for the sample, and to adjust for the schools/individuals that did not participate in the survey. The variables are listed as follows:

A. Dependent variable

The dependent variable, STEMPATH, is *whether or not a student is on a path to a STEM career* (coded 1 for yes). The determination of STEMPATH is based on coursework, school related activities, and application of math related skills in school. In the first round of data collection, STEMPATH is determined either by a student's participation in *science/math fair* or *vocational/tech skills competition* or by their responses on a 5-point scale (1 for "Never" to 5 for "Every day or almost every day") to *how often does problem-solving in math class*, *how often explains work to math class orally* and *how often uses computers to analyze data in math class*. STEMPATH is coded as "Yes" if they participated in a science/math fair, vocational/tech skills competition, or if they responded to any of the school application questions with a 2 ("Rarely") or greater. The use of these variables to determine STEMPATH is supported by current research that suggests students who participate in STEM competitions are more likely to express interest in a STEM-related career at the end of high school than are students who do not participate, even when students' prior career interest in STEM is controlled for [20]. The amount of time students use classroom time to apply, communicate, and

analyze data are important skills that STEM employers look for, according to the U.S. Bureau of Labor Statistics' publication *Occupational Outlook Quarterly* [21].

In the second round of data collection, variables related to student coursework taken (as reported by the student) and whether or not they have taken or plan to take an Advanced Placement (AP) Examination. STEMPATH is coded yes for any student that have already taken or plan to take an AP exam or responses to have taken least ½ year of any of the following courses: *Chemistry, Physics, Pre-Calculus, Calculus, Principles of Technology.*

For the third round of data analyzed, students' completed high school transcript were used and STEMPATH was based on total Carnegie units, which is equivalent to a one-year academic course taken one period a day, five days a week. STEMPATH is determined by giving value of +1 for 1 Carnegie unit and +2 points for 1 Carnegie unit of Advance Placement (AP) courses. Reference [22] analyzed course taking leading to college application and course registration into a STEM major by looking at high school grades in math/science courses and found that all grades received in math/science courses beyond level 1 (9th grade/high school freshman level) increased the probability of continuing the path to higher level math/science courses at the university level. This study does not use grades, but credits earned for passing computer science, engineering, mathematics, and science courses.

B. Independent variables

Data are analyzed with control variables for Race (1 for Black or African-American, Non-Hispanic) and Sex (1 for Male).

Student's Self-efficacy: A individual level composite variable based on student responses to a 4-point scale (1 for "Almost never" to 4 for "Almost always") in the base year (10th grade) of ELS:2002. The participants responded to how often they: *think math is fun, can do excellent job on math tests*, *can understand difficult math texts*, *can understand difficult math class* and *can master math class skills.* Responses were averaged and coded as a measure of the student's belief their own mathematical ability ($Cronbach's\ alpha\ (\alpha) = .90$, $Mean\ (M) = 2.48$, $Standard\ Deviation\ (SD) = 0.78$).

School Facilities: A school-level composite variable based on administrator responses to a 4-point scale (1 for "Not at all" to 4 for "A lot") in the base year (10th grade) of ELS:2002. Participants responded to if at the school level: *learning hindered by poor science labs*, *learning hindered by too few computers, learning hindered by lack of multi-media* and *learning hindered by poor voc/tech equipment/facilities*. Responses were averaged coded as a measure of how much the school's resources affected the student's ability to land on the STEM career trajectory ($\alpha = .80, M = 1.78, SD = 0.67$).

Parent Socialization Messages: Individual-level variables based on student and parent responses to a 4-point scale in the base year (10th grade) of ELS:2002. Participants responded to whether:

Parents expect success in school ($\mathrm{M} = 3.46, \mathrm{SD} = 0.66$), *Most people can learn to be good at math (parent)* ($\mathrm{M} = 3.00, \mathrm{SD} = 0.62$), *Parent contacted school about helping with homework* ($\mathrm{M} = 1.39, \mathrm{SD} = 0.71$), *Must be born w/ability to be good at math (parent)* ($\mathrm{M} = 2.83, \mathrm{SD} = 0.68$), *How often parents checks homework* ($\mathrm{M} = 2.86, \mathrm{SD} = 1.06$), *How often parents help with homework* ($\mathrm{M} = 2.50, \mathrm{SD} = 0.92$).

Stem Path Average: School-level variable based the average STEMPATH per school. ($M = 0.61, SD = 0.11$)

V. Methods

Data are analyzed using multi-level logistic and longitudinal models. Multi-level modeling is used because of the hierarchical nature of the data, with students (level 1) nested within schools (level 2). The dichotomous STEMPATH outcome suggests using the Bernoulli logistic regression with values that converted into an odds ratio with 1 representing "equal chance of occurring and not occurring", < 1 representing "reduced odds of occurring" and > 1 representing "increased odds of occurring" The logit estimates are transformed into odds ratios for reporting. The data is analyzed using statistical software R (version 3.4.2, 2017) with package for generalized linear modeling lme4 [23]. Aside from control variables (race/sex), all independent variables are grand mean centered. To test mediation and moderation effects, the estimates of STEMPATH was compared to a base model containing only control variables with models with parent and school variables separately and collectively.

VI. Results

Table 1 presents the results from the multi-level logistic regression models. Comparison of nested models was done using maximum likelihood ratio test results for successive models' goodness of model fit. The comparison of Model 1 (base model) to Model 4 (full model) showed a significant ($p < .0001$) difference between the models ($\chi^2 = 65.81, df = 14, N = 6582$).

Model 1, which is this study's base model showing the estimates (in logit units) that are converted and displayed as odds ratios (Fig. 1), shows how the odds of being on engineering career trajectory are affected by the control variables (race, sex) and independent variable (self-efficacy). Negative estimates correspond to reduced odds and positive estimates correspond to increased odds and significant estimates are marked with asterisks. Fig. 1 shows that being African-American decreases the odds of being on an engineering career trajectory by a factor of 0.85 (compared to not being an African American) and having high mathematics self-efficacy increases the odds of being on an engineering career trajectory by a factor of 1.55.

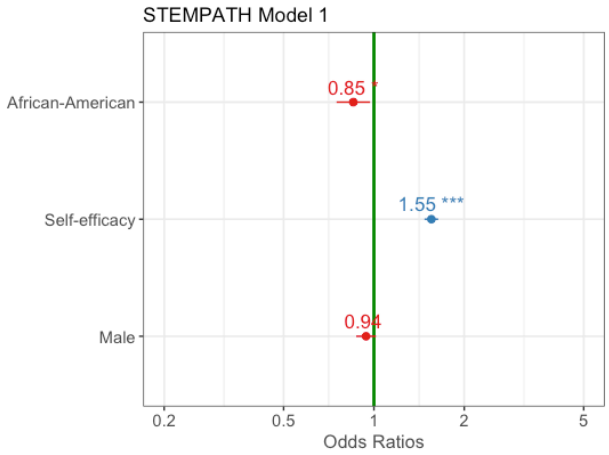

Fig. 1. STEMPATH Model 1

Model 2 (Table 1) is the estimation when parent socialization messages are added along with the interaction of self-efficacy with each of the parent socialization variables. None of the interactions are significant, which indicates none of the parent socialization variables are moderators of the self-efficacy/career trajectory relationship, but there are significant individual parent messages. Parents who expect success in school, believe people can learn to be good at math and check homework more frequently all increase their child's odds of being on an engineering career trajectory (Fig. 2). Parents who more frequently helped with their child's homework, either by contacting the school or directly helping, decrease their child's odds of being on an engineering career trajectory (Fig. 2).

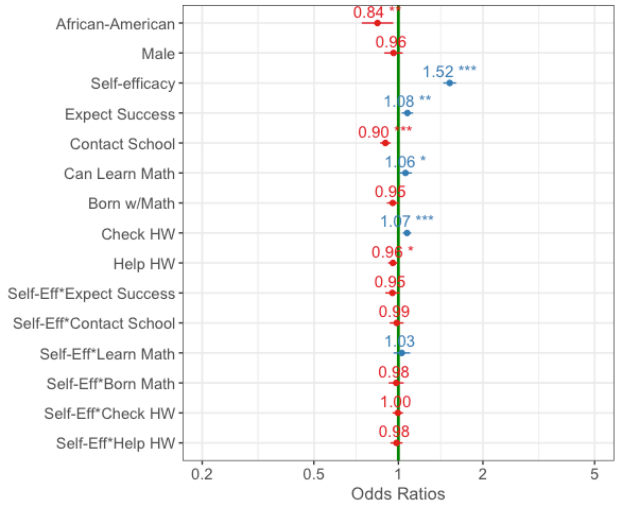

Fig. 2. STEMPATH Model 2 (parents)

Model 3 (Table 1) is the estimation when the school facilities and interaction of self-efficacy and school facilities are included (without the parent socialization messages), however, there are no significant effects of either on the career trajectory nor are there any changes (from Model 1) in the self-efficacy and race factors that remain to be significant.

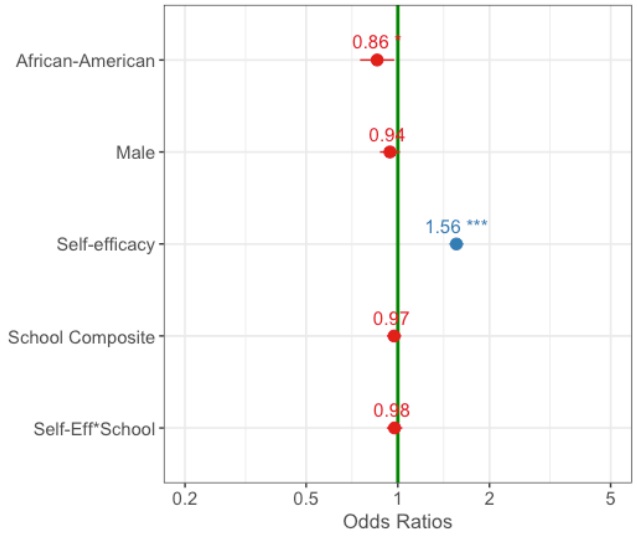

Fig. 3. STEMPATH Model 3

Model 4 of Table 1 represents the full model containing all independent variables with their interactions. The inclusion of school facilities with parent messages did not change the effects from Model 2 and the significant effect of being an African American and high self-efficacy remained the same as previous models.

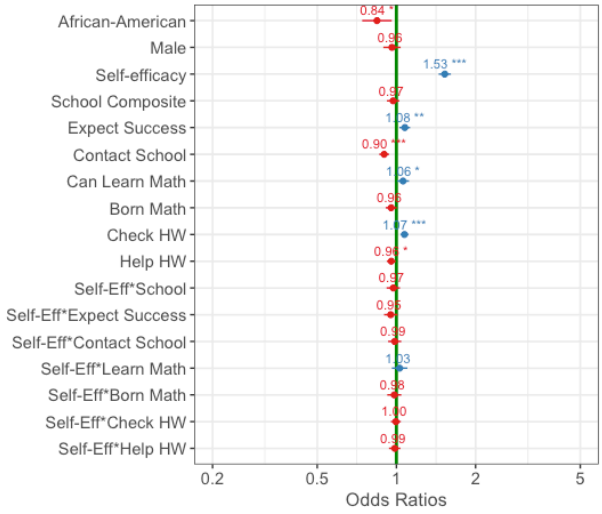

Fig. 4. STEMPATH Model 4 (full)

VII. Conclusion/Discussion

Career trajectory research remains important to build STEM pipelines for underrepresented minority social groups. Filling the pipeline with minorities can help with the workplace diversity of the STEM industry and provide gains in socio-economic status of minorities. While much research has been done on career choice and path at the post-secondary level, the requisite knowledge and skills are obtained during high school. Close examination must be done at the K-12 level to properly guide students to a career path with higher than average earnings and job opportunities.

This study shows that for African-Americans students, the odds of being on a career trajectory for an engineering pipeline in high school are affected by mathematics self-efficacy and parents' socialization messages. The results of the hypotheses stated previously are as follows:

Hypothesis 1: Career engineering trajectory is mediated by parents' math socialization and/or school environment. This study found no significant results for this hypothesis. The overall effect self-efficacy had on the outcome remained significant and unaltered by the inclusion of parent and/or school facility variables.

Hypothesis 2: Career engineering trajectory is moderated by parents' math socialization and/or school environment. This study found no significant results for this hypothesis. The overall correlation of self-efficacy and the outcome, as measured by the estimates of interactions, remained non-significant and unaltered by the inclusion of parent and/or school facility variables.

Hypothesis 3: Parent socialization messages are affected by the school environment. This study found no significant results for this hypothesis. The inclusion of parent socialization messages with school variables in full model did not alter the effect of the school variables.

Hypothesis 4: The intersection of an adolescents' race and gender effects the impact of socialization messages received by parents. In every model in the analysis, being African-American resulted in significant decreased odds of being on an engineering career trajectory. The effect of being a male also produced decreased, but not statistically significant odds. These effects remained consistent throughout the study, and when parent socialization messages were added in the analysis in Model 2, there were varied positive and negative effects of the parent messages for African-American males.

Hypothesis 5: Socialization messages influences African-American males' career trajectory. This study found significant results that suggest that parents who expect success in school, believe people can learn to be good at math, and check homework more frequently increase their child's odds of being on an engineering career trajectory. Parents who more frequently helped with their child's homework, either by contacting the school or directly helping, decreased their child's odds of being on an engineering career trajectory (Table 3 and Fig. 4).

Hypothesis 6: School environment has as effect on African-American male students career trajectory. This study found no significant results.

The African-American males analyzed in this study demonstrate the possibility of a pipeline to engineering careers and how socialization messages can increase/decrease odd of being on that pipeline. Parents and teachers must be made aware of attitudes and practices that may alter a child's chances after being identified as being on an engineering career trajectory, so they can make the necessary adjustments that will benefit the child. For the students analyzed, being African-American and a male decreases the odds of existing on a STEM pipeline, which is in need of African-American males. For those interested in increasing participation of African-American males in engineering careers specifically and/or STEM careers in general, it is important to not only identify students who may be viable candidates, but it is equally important to limit barriers that exist at every stage of a child's education that may decrease a student's chances of continuing on the desired trajectory.

While this study is limited to the influence of parents' socialization messages, future research must continue to see how other socializers affect African-American males' career trajectory, and how the different socialization sources interact with each other to contribute to a student's engineering career trajectory. This study does not offer any specific pedagogical modifications related to content, but it does advocate for focused communication with parents about how to properly support their child in a way that increases students' chances of being on the proper career trajectory.

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TABLE I. GENERALIZED LINEAR MIXED MODEL FIT BY MAXIMUM LIKELIHOOD (LAPLACE APPROXIMATION)

Fixed Effects		**Model 1**	**Model 2**	**Model 3**	**Model 4**
Race: African American		-0.16(0.07)*	-0.17(0.07)**	-0.16(0.07)*	-0.17(0.07)*
Sex: Male		-0.06(0.04)	-0.04(0.04)	-0.06(0.04)	-0.04(0.04)
Self-efficacy composite (alpha = .90)		0.44(0.03)***	0.42(0.03)***	0.44(0.03)***	0.42(0.03)***
School facilities composite (alpha = .80)				-0.02(0.03)	-0.03(0.03)
Parents expect success in school			0.07(0.02)**		0.07(0.02)**
Parent contacted school about helping with homework			-0.11(0.02)***		-0.11(0.02)***
Most people can learn to be good at math-parents's opinion			0.06(0.03)*		0.06(0.03)*
Must be born w / ability to be good at math-parent's opinion			-0.05(0.02)		-0.05(0.02)
How often parents checks homework			0.07(0.02)***		0.07(0.02)***
How often parents help with homework			-0.05(0.02)*		-0.05(0.02)*
Self-efficacy/School Composite (Interaction)				-0.02(0.03)	-0.03(0.03)
Self-efficacy/Expect Success (Interaction)			-0.05(0.03)		-0.05(0.03)
Self-efficacy/Contact School (Interaction)			-0.01(0.03)		-0.02(0.03)
Self-efficacy/Learn Math(Interaction)			0.03(0.03)		0.03(0.03)
Self-efficacy/Born Math(Interaction)			-0.02(0.03)		-0.02(0.03)
Self-efficacy/Parents Check (Interaction)			-0.00(0.02)		-0.00(0.02)
Self-efficacy/Parents Help (Interaction)			-0.02(0.03)		-0.02(0.03)
Intercept		0.48(0.03)***	0.48(0.03)***	0.48(0.03)***	0.48(0.03)***
Random Effects					
Race: African American		0.00(0.01)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Sex: Male		0.00(0.01)	0.00(0.01)	0.00(0.01)	0.00(0.00)
Self-efficacy composite (alpha = .90)		0.00(0.00)	0.00(0.01)	0.00(0.00)	0.00(0.01)
School STEMPATH Average		9.87(3.14)	9.83(3.13)	9.73(3.12)	9.73(3.12)
Intercept		3.50(1.87)	3.45(1.86)	3.43(1.85)	3.37(1.84)
AIC		25437.7	25397.6	25440.1	25399.9
BIC		25587.6	25642.2	25605.8	25660.3
logLik		-12699.8	-12667.8	-12699.1	-12666.9
deviance		25399.7	25335.6	25398.1	25333.9
df.resid		19727	19715	19725	19713
	n (observations/wave)	6582	6582	6582	6582
	N (schools)	593	593	593	593

Fixed effects: Natural logarithm of odds ratio (logit) followed by robust standard error in parentheses
Random Effects: Variance (Standard deviation)
**p < 0.05, **p < 0.01, ***p < 0.001*