Higher Education Studies; Vol. 3, No. 1; 2013
ISSN 1925-4741 E-ISSN 1925-475X
Published by Canadian Center of Science and Education

From Access to Success: Identity Contingencies & African-American Pathways to Science

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Received: September 26, 2012 Accepted: October 17, 2012 Online Published: January 25, 2013

doi:10.5539/hes.v3n1p1 URL: http://dx.doi.org/10.5539/hes.v3n1p1

Abstract

We conducted a mixed-methodological study of matriculation issues for African-American students in science. The project compares the experiences of students currently majoring in science (N= 304) with the experiences of those who have succeeded in earning science degrees (N=307). Using a 57-item Likert scale questionnaire, participants were asked about their experiences based on theories that are commonly used to explain matriculation issues (*Stereotype Threat, Microaggressions, Communities of Practice*). The results of the study revealed that although both groups recognized the major role of race in their experiences, the primary factor distinguishing between groups was a sense of alignment with the community (*Communities of Practice*) and their differences with experiencing *Microaggressions*. Those who achieved success were far more likely to report a weak sense of belonging and were far more likely to report experiences with *Microaggressions*. By contrast, students were more likely to feel comfortable with the science community and less likely to report experiences with *Microaggressions*. The findings of this study are indicative of the pervasive impact of racial bias and conflict as a gatekeeper in providing access to science careers.

Keywords: African-American, science, college access

1. Introduction

There is an old saying in the U.S. African-American community that simply refers to "The Black Tax". As a construct, the idea of the Black Tax suggests that because African-Americans face social injustice, their success comes with an additional price known by the colloquial phrase "The Black Tax". Carroll (1998) describes this phenomenon as African-Americans experiencing mundane environmental stress. Her argument suggests that group membership in the Black community generates additional stress as African-Americans negotiate inequality in professional and academic spaces.

Psychologists described the challenges African-Americans face using the idea of *social identity contingencies*. Purdie-Vaughns, Steele, Davies, Ditlmann, & Crosby (2008) describe social identity contingencies as the "judgments, stereotypes, opportunities, restrictions, and treatments that are tied to one's social identity in a given setting (p. 615)." According to their lens certain individuals experience shifts in their identities due to context. For example, what it means to be a scientist is subverted by the additional stress of racial stereotypes that highlight what it means to be *African-American* scientists in a particular setting. The expectations and stereotypes associated with group membership can heighten the impact of students' identities in different contexts. Few studies have examined how participating in the science community signals feelings of threat and conflict for under-represented scientists (*for exceptions see Gilbert & Yerrick, 2001*). Given the small number of African-American scientists, a social contingency lens may highlight how contemporary pipeline challenges in science education shape the feasibility of students' matriculation through the science pipeline. Accordingly, as individuals identify with the combined context of their ethnic identity and identity as scientists, they run the risk of the potential threat of managing social identity contingencies.

This research project is fundamentally concerned with what happens as African-Americans attempt to earn degrees in science. Although reports highlight a contemporary crisis associated with issues of equity and access to science, the reasons for those challenges are still unclear. A 2010 report of the National Committee of Educational Statistics (NCES) reported only 30.7 percent of African-Americans complete high school Physics and only 25.4% complete a combination of Biology, Chemistry and Physics (NCES, 2010). This would suggest

that as African-American students enter college they would be likely to have few other African-American peers. As a result, we should consider how issues of social identity contingencies and mundane environmental stress might impact students' experiences with science.

Given these concerns, national reports from the NCES (2007) provided some interesting information regarding how these contingencies may play out. When reflecting on the leading college majors for African-American students, NCES reports African-Americans have the highest percentage of bachelor's degrees in business (25 percent) and the lowest in engineering (3 percent) of any ethnic group. This suggests that African-American students are avoiding science careers at rates much higher than their counterparts. These results highlight how many African-Americans are not entering science majors and are changing their majors once they enter the science pipeline.

To add complexity to this issue, a National Science Foundation (NSF) report documented how the top 10 institutions graduating African-American students who earned doctorate degrees in science were Historically Black Colleges and Universities (NSF, 2007), referred to as HBCUs. (Note 1) This finding is further complicated considering that most of these students matriculated to traditionally white institutions to earn their doctoral degrees. Despite the fact that only 6% of all African-American college students are enrolled at HBCUs, 28.8% of all Black students who earn bachelor's degrees in science graduate from these types of institutions (NSF, 2007).

1.1 The Centrality of Race

If we assume that African-American students arrive to their early school experiences with equitable abilities, then the issue of race becomes central to the analysis of why the current disparities exist. Although race is often used as a key feature to explain differential performances in science, research does not offer great explanations of how race plays a role in the way students are able to earn degrees in science. Ultimately, race becomes a meaningless descriptor of individuals' backgrounds if the term does not provide insights about the academic and social experience of students who matriculate through careers in science. Such a perspective is especially pertinent when considering how African-American perform significantly better in science when they attend HBCU.s.

If race is operationalized as a descriptor and not as a salient variable in the achievement of African-American students, then research on these pipeline issues is limited to an ability to *describe* the problem as opposed to being able to *explain* the potential sources of these problems. This research project seeks to operationalize race as a contributing factor, by examining how Black Scientists and Black Science majors perceive race as a salient component of their academic experiences. To contribute the volumes of research that describe the pipeline challenges for African-Americans in science we assessed the explanatory potential of leading educational theories that explain differences in groups' performance. To build a framework on how race is a contributing factor, we draw on research in the broader educational community that explores the key features of race and identity as operationalized factors in students' experiences.

2. Theoretical Framework

Although the idea of social identity contingencies is a psychological term, we applied its basic premise to a study of sociocultural issues in science education. To explore the types of social identity contingencies that may impact students' participation in science, we sought to assess the predictive power of perspectives traditionally not applied to studying access to Science, Technology, Engineering and Mathematics (STEM) careers (Fordham, 1996; Mehan et al., 1996; Ogbu, 1982; Solórzano, 1998; Wenger, 1999). The educational research community offers a number of widely used sociocultural theories used to explain differences in access and participation (Fordham, 1996; Mehan et al., 1996; Ogbu, 1982; Solórzano, 1998; Wenger, 1999). In exploring how the pipeline challenges involving African-Americans could be explained by prominent educational theories, we designed an instrument that assessed a set of theories best described as theories of participatory structure (Fishman, 1989; Irving; 1988; Solórzano, 1998; Wenger, 1999).

2.1 Theories of Participatory Structure

There are a number of theoretical perspectives that emphasize how identity and participatory structure impact access (Ogbu, 1982; Solórzano, 1998; Wenger, 1999). There are two critical assumptions that support these perspectives: (1) Simply having access to a community does not mean that all community members share common experiences within the community (Wenger, 1999). A participatory lens identifies how access does not equate to equity if an individual's cultural experiences and social identity contingencies are different. (2) These perspectives assume that cultural and gender identities matter (Fordham, 1996; Solórzano, 1998). These theoretical lenses identify how individuals who exist within smaller cultural communities, like the science community, have perceptions of self that are constantly negotiated as a means of promoting community

membership. Together, theories of participatory structure have the potential to provide an intriguing framework to investigate access to the science community.

One framework within this domain utilized a social science construct known as *Microaggressions* (Solórzano, 1998). This research examined subtle, racially motivated interactions between students and faculty. Solórzano, Ceja, & Yosso (2000) described how simple interactions like receiving compliments on ability to speak, or being asked to speak on the behalf of their ethnic group equated to subtle forms of racism, or *Microaggressions*. The value of this theoretical lens is in its capacity to explain Black Scientists' and Black Science majors' experiences with the specific social identity contingencies that occur in the form of *Microaggressions*.

In another participatory structure theory, Etienne Wenger's (1999) community of practices perspective offers a rich framework for understanding issues of equity of participation. Although not usually applied to issues of race, we explored Wenger's three sub-constructs of *Imagination*, *Engagement*, and *Alignment.* These lenses explain why individuals in the same community can have vastly different experiences. This perspective included (a) how one's *Imagination* could provide a filter through which their participation in the community could be impacted, (b) the way an individual *Engages* in the community can alter how they experience the community, and (c) how their perceived *Alignment* with the normative practices of the community impacts their experience. Collectively, these three frameworks provided us with a dynamic lens through which to examine how individuals participate in the science community.

Wenger (1999) used the construct of *Imagination* to explain how potential differences in the way one imagines, or perceives, the community may impact an individual's experience. Conversely, experience can alter one's preconceived perception. He describes *Imagination* as a tool for framing expectations of the community in which you are participating. For example, a Black Science major may have imagined a community that is unwelcome to Black Scientists. Whether an imagined experience is accurate or not, the imagined interaction can impact how an individual will engage with the community. If they find that the community is welcoming, they can alter their expectations. Of course, the alternative can be true. Conversely, an individual may enter the science community with an "imagined" expectation that they will be full members of the community. Small interactions such as not being invited to social events or being asked why they choose toattend a Historically Black College or University (HBCU) may contradict the "imagined" notion of full acceptance. Whether one's imagined interactions are confirmed or proven false, Wenger's lens helps scholars of science education think critically about how an individual's imagined participation in the community will have an impact on how they can actually participate within that community.

A second aspect of Wenger's framework involves examining the diversity of ways an individual can "engage" in the community. His use of *Engagement* implies that people within a community participate in different ways. Certain individuals may become fully engaged, while others may have their input ignored. Such a perspective insinuates that, although individuals may be a considered "members" of the group, they may be limited to being non-valued contributors. This devaluing would be seen as being a member of a community, but not *engaged* in the community. To contrast this position, a valued individual may find their input is both understood and applied. For our examination of Black Scientists and Black Science majors, we can explain *Engagement* as an important feature in the matriculation of Black Science majors through the science pipeline.

The last of Wenger's sub-constructs used in our study involves a critical examination of an individual's alignment within a community. As individuals contribute to communities, the ways that members align themselves within a community could be vastly different. For some, aligning with the community of norms generates one type of participation, while others may choose to align with the non-normative practices of a community. Wenger explains how alignment can explain group membership and identity in the following.

> Through alignment, the identity and enterprise of large groups can become part of the identities of participants. Demanding or inspiring alignment is a form of identification because the power, individual or collective, to generate alignment extends our identity to the energy of those who align themselves. An inspiring leader or an authoritarian parent will incorporate the effects of their inspiration or control into their own identities. Members of a dedicated professional group will identify with the actions of their colleagues (p. 196).

The idea that an individual can "identify with the actions of their colleagues" is critical as we consider how such interactions are symbols of belonging. The extent to which non-scientific activities are seen as cues to being a normative participant can shape how people are perceived as aligned with the community. This perspective offers a lens to analyze pipeline issues as we investigate how Black Scientists and Black Science majors may align themselves differently with the science community. A case in point involves a scenario where a Black

Scientist may feel a strong sense of alignment with the cultural practices of his or her profession. These may include sharing common cultural preferences for music, food, and knowledge about science, personal interests, and family values. Conversely, other Black Scientists may experience feelings of cultural conflict because their musical interests, religious affiliations, taste for food, personal interests, and family values may be vastly different than the norms of the science community. Ultimately, this lens provides us with a theoretical resource to examine how differential experiences may be rooted in the individual's sense of alignment with the science community.

Another perspective used for our study was *Achievement Ideology* (Mehan, Villaneueva, Hubbard, & Lintz (1996). According to Mehan et al. (1996) an *Achievement Ideology* is one where students believe academic success in school holds a meaningful relationship to life success. For students from disenfranchised communities, a belief that school success is a mediator to resisting a larger issue of cultural oppression can have a profound impact on students' school experience. If an individual truly believes that high performance in school can change their social situation, it is reasonable to expect students to perform according to that belief. In applying that lens to the matriculation into science careers, we sought to examine the extent to which scientists and students potentially differed in their *Achievement Ideology*.

Another perspective we explored in our study was our participants' standpoint on Oppositional Identity. Ogbu's (1982) seminal research on African-American culture reasoned that some African-Americans developed an Oppositional Identity or *Cultural Inversion* perspective towards society. This position suggested that in response to years of cultural oppression, Blacks rejected mainstream ways of being that included speaking, acting, and participating in school. According to Ogbu many African-Americans had to weigh whether to reject their identity as African-Americans to accept schooling practices or to oppose school practices. His work suggested a noted difference between immigrant African-Americans and non-immigrant African-Americans in their approaches to assimilating mainstream academic practices that are assumed to be white culturally. In applying this lens to African-American scientists, we sought to explore if our participants viewed issues of assimilation to the culture of science either similarly or differently.

In a similar perspective, we applied the theory of *Fictive Kinship* (Fordham, 1996) to our analysis. *Fictive Kinship*, according to Fordham, is the idea that there is an imagined family relationship between African-American people. As a result, African-Americans expect all other African-Americans to share cultural features. These features can include ways of speaking, dressing, and engaging with each other. More specifically, a *Fictive Kinship* lens would suggest that one African-American would serve as a representative of the entire race of people. In applying that lens to this manuscript, we sought to examine how our participants' sense of cultural ownership or *Fictive Kinship* could serve as a predictor of difference between our participating groups.

Given the complex nature of the above theories of participatory structure, we seek to identify the extent to which either of these perspectives can offer useful explanations for the differences between those who have already made their way through the science pipeline (Black Scientists) and those currently involved in the pipeline (Black Science students). This study uses a theoretical lens that applies each of the theories as a factor in social identities to examine how the experiences can be better understood of those who have earned degrees in science and those in the process of earning science degrees.Through this exploration, we hope to gain an understanding of how access to science is provided to those who are traditionally on the margins of the science education community.

3. Research Question

Given the diversity of theoretical perspectives available to explain the pipeline issues, we sought to explore the following research question. Which contemporary theoretical perspectives on access and participation best explain the differences between African-American science students in the pipeline and those who have successfully matriculated into STEM careers?

4. Methods

To assess how these theoretical perspectives carried predictive power we conducted a survey of African-American scientists and African-Americans majoring in science. Our design was simple. We built a survey instrument (*see Appendix*), based on items derived from each of the perspectives described previously, to assess each of these theories as a predictor of the experiences of both groups. We designed a survey with an equal number of items per theoretical construct and with short answer questions to elicit open-ended responses for explaining individual perceptions of each of the theoretical constructs.

We used a 57-item survey that examined 7 construct scales, 14 demographic items, and short answer, qualitative response questions. Using a standard Likert scale ranging from "Disagree Strongly" (score = 0) to "Agree Strongly" (score =4), each of our 7 scales concluded with open-ended questions that elicited additional thoughts. We engaged in an iterative design process where we piloted the instrument and found that it took approximately 15 minutes to complete. We conducted internal consistency measures on the n=304 Black Scientists and n=307 Black Science majors who had completed the survey, and calculated a Cronbach's alpha score of .691. This study reports the quantitative results of our analysis.

4.1 Who Counts as a Black Scientist?

This study was concerned with assessing the experiences of individuals of diverse African-American heritage involved in STEM. We will now use the colloquial term "Black" to describe a diversity of participants, from immigrants of Africa, the Caribbean (including Cuba), and South America who may consider themselves "Black", to encompass a larger demographic. Additionally, to assess the experiences of those science majors who may consider themselves Black, but by not being U.S. citizens would not consider themselves African-American; we selected a term most likely to promote greater participation. As such, we used the term "Black Scientist" to reflect the experiences of a diversity of individuals who consider themselves Black and who are involved in Biology, Chemistry, Physics, Engineering, Nursing, Dentistry, Science Education, Geology, Earth Sciences, Environmental Sciences and other broadly defined science fields.

A series of recruitment activities was used to draw attention to our online survey instrument. First, we called and emailed 253 Science Department Chairs from across the U.S., asking these department heads to forward our survey. Second, we attempted to access online social networks by posting information about our study on Facebook™ and Twitter™. Third, we sought to leverage leading organizations (e.g., *The National Society of Black Engineers, The National Institutes of Health Black Scientist Association*) to gain access to their database of Black Scientists. Ultimately, the results of the recruitment process yielded the n=304 Black Scientists and n=307 Black Science majors nation-wide.

4.2 Participants

The participants of the study include a diverse network of ethnic backgrounds and scientific disciplines.Ninety-eight percent of this sample reported U.S. citizenship. The gender distribution of the study was 48% male and 52% female. We experienced great diversity in the fields of expertise of the participants. The scientific fields most commonly represented were Engineering (31%), Medical/Nursing (26%), Biology (18%), and Science Education (8%). Approximately 80% of the practicing scientists reported receiving at least a Master's degree, with 27% of the sample holding a Ph.D. and 19% possessing an M.D. The percentage of individuals earning advanced degrees reflected a population of individuals who are often difficult to identify. Sixty-five percent of the respondents reported being raised by both their mother and father, while 26% indicated being raised in single parent homes led by mothers. Nearly 80% of the sample reported being ranked in the top 10% of their high school graduating class.

The Likert scale responses to the *Alignment* survey items and the responses to the corresponding open-ended survey questions were analyzed quantitatively and qualitatively.Quantitative analyses included factor analysis, one-tailed t-tests at $p < .05$, and the determination of effect sizes.The findings that follow reflect the result of that analysis.

5. Findings

5.1 Analysis 1: Confirmatory Factor Analysis

To provide an initial assessment of how each theoretical construct explains differences between scientists and Black Science majors we conducted a factor analysis. Of 57 items in our survey, there were 41 variables corresponding to the specific theoretical constructs described earlier. To assess how each theory explained potential differences, the factor analysis provided us a means to explore the largest areas of agreement and disagreement between both groups (see Table 1).

Table 1. Results of the primary factor analysis

	Composite Variables A	Factor Loading B
1	**Microaggressions**	(alpha = .835)
2	There are occasions where I experience subtle racism because I am a *(Black Scientist/ Science major).*	.800
3	There are instances in *(science meetings and conferences/science classes and laboratories)* where I experience subtle forms of racism.	.794
4	People say things to me that are racist because I am a *(Black Scientist/ Science major)*.	.749
5	There are instances in which I feel that people speak to me differently, but not overtly racist.	.646
6	**Achievement Ideology**	**(alpha = .770)**
7	I believe that my job title is solely related to my (achievement in the field/ the field in which I major.)	.868
8	I believe that my salary is solely related to my (achievements in the field/achievement in the field in which I major).	.828
9	I believe that my prestige in my scientific (field/major) is solely related to my (achievements in the field/ in the field which I major).	.695
10	**Cultural Inversion**	**(alpha = .659)**
11	I continue to engage in cultural activities that others consider Black regardless of what the mainstream community thinks.	.796
12	I enjoy engaging in Black culture, even when it makes non-Black (scientists/students) uncomfortable.	.724
13	**Alignment**	**(alpha = .686)**
14	My Black identity provides me a sense of belonging to the scientific (community/major).	.822
15	As a Black person, I feel like others see me as a legitimate member of the scientific (community /my science major).	.659
16	**Fictive Kinship**	**(alpha = .838)**
17	My success or failure in my (science career/attempting to achieve a science degree) represents all other Black (scientists/science majors).	.892
18	My performance on the (individual tasks of my job/grades and performance on examinations) represents all other Black (scientists/students).	.880
19	**Engagement**	**(alpha = .706)**
20	As I engage in the science community, I feel like a member of the community because of my being Black.	.568
21	The extent to which I can relate to the other (scientists/science majors) is limited because of my being Black.	.547

The factor analysis presented above allowed us to determine which of the theories achieve greater levels of agreement and difference between our participant populations. By exploring this factor we were better able to understand how these items could be reduced into more meaningful indicators of potential difference. As indicated in Table 1, we were able to reduce the macro level findings into a more manageable composite of subscales. Said differently, we were able to identify how each of our groups *(Black Scientists and Black Science students)* scored on questions from each theoretical construct. That score would then allow us to see how a score on one type of item was correlated to scores on another item. By taking the alpha scores of each question, we could determine the rate of agreement for each subscale, based on the mean score of each question within the scale. As indicated in Table 1, the items that address the theoretical constructs of *Microaggressions* (Solórzano, 1998), *Achievement Ideology* (Meehan et al., 1996), *Cultural Inversion* (Ogbu, 1986), *Alignment* (Wenger, 1999*in Lit. Cited it is 1999*), *Fictive Kinship* (Fordham, 1996), and *Engagement* (Wenger, 1999) were all identified as statistically significant factors. With scores of .835, .770, .659., .686, and .838 we were able to identify that these constructs were our strongest predictors of our participants' thoughts on their experiences. As a result, we were able to use these six composite variables for our secondary analysis.

The results indicate that subscale items like the *Microaggressions* scale with factor loadings of .800, .794, .749, and .646 and an alpha value of .835 can be viewed as primary factors in explaining the commonalities and differences between Black Scientists and Black Science majors. Said differently, given the relative uniformity of students' responses and scientists' responses on these items, a detailed review of these items would help highlight how these two groups perceived issues of racial *Microaggressions* in science similarly or differently. These results are useful in offering insights into our research questions. Explanation of the differences across these items offers the best potential explanation of the differences between those who were able to matriculate into science and those currently majoring in science.

Additionally, the significant results on factor items exploring *Achievement Ideology*, *Cultural Inversion*, and *Alignment* measures all suggest that we conduct a more focused assessment of how these subscales (Table1) are predictors of the difference between our participants. Upon recognizing the significance of these factors as indicators of variability, each of these subscales was used for subsequent analysis. The six composite measures, with their respective measures of internal consistency and the factor loadings of their constituent items, are summarized in Table 1.

5.2 Analysis 2: T-Tests Analysis

Given the above results, we were able to use our most accurate scales to measure the differences in perspective across our participating groups. Table 2 summarizes descriptive statistics and t-test results comparing the mean scores between Black Scientists and Black Science majors. Of these six variables, the means between Black Scientists and students are statistically significant at our preset 5% alpha level for three concepts *Microaggressions* (cell F1), *Achievement Ideology* (F2), and their *Alignment* (F4). This would suggest that the biggest difference between Black Scientists and Black Science students is associated with their experiences with racism (*Microaggressions*), perspective on the value of academic achievement (*Achievement Ideology*), and their sense of connection to the community of science (*Alignment*).

Before we adopted the results of these tests, we had to consider whether not the mere number of t-tests was ultimately impacting our results. To address this concern and to reject null hypothesis that population means between our two groups are not similar, we conducted a Bonferroni adjustment. We accounted for the increased probability of Type I error due to the six tests conducted. As a result, we found that the mean differences between Black Scientists and students for the composite variables of *Microaggressions* and *Alignment* remained statistically significant once inflation in Type I error is accounted. Said differently, the two theoretical categories that offered the most powerful assessment of the difference between groups were theories of *Alignment* and *Microagressions*. The results of t-tests on both measures offered statistically different results where each group's perception of their experiences with racial *Microaggressions* and their differing sense of alignment with the science community were considered. Given our initial research question about the predictive power of leading theoretical explanations, we can argue that the notions of *Microaggressions* (Solórzano, 1998) and *Alignment* (Wenger, 1999) emerged as our most powerful explanatory perspectives.

The results of the adjusted t-test enabled us to focus our attention on how the two significant theoretical subscales, *Microaggressions* and *Alignment*, were useful indicators of any differences between our Black Scientists' response and those of our Black Science majors. Solórzano's (1998) suggestions that subtle forms of racism impacted students' experiences and Wenger's (1999) idea that individuals' sense of alignment within a community impacts the type of their interaction emerged as useful analytical tools for exploring the differences between Black Scientists and Black Science majors.

Table 2. Descriptive and t-test analyses of composite variables

		A	B	C	D	E	F	G
			Scientists/ Professionals		Students			
	Survey Factors	**Range**	**M (n)**	**SD**	**M (n)**	**SD**	**t (df)**	**Cohen's d**
1	**Microaggressions**	0.16	9.44 (293)	3.58	7.84 (230)	4.39	4.48*** (437)	.405
2	**Achievement Ideology**	0.12	6.10 (292)	3.00	5.52 (225)	3.01	2.16* (515)	.193
3	**Cultural Inversion**	0.8	6.43 (294)	1.68	6.51 (231)	1.60	-.569 (523)	.049
4	**Alignment**	0.12	5.95 (297)	2.64	6.64 (231)	2.71	-2.93** (526)	.259
5	**Fictive Kinship**	0.8	3.93 (295)	2.60	4.05 (230)	2.65	-.550 (523)	.046
6	**Engagement**	0.8	5.23 (297)	2.12	5.13 (231)	2.22	.526 (526)	.046

(2-tailed) *p<.05 **p<.001 ***p<.001

Table 2 documents how the Black Scientists that participated in this study were statistically more likely to report the larger commonality of experiencing *Microaggressions* (cell B1) than did their student counterparts (cell D1). This suggests that scientists and students reported different experiences with racial *Microaggressions*. The practical significance of this discrepancy corresponds to a moderate effect size of .405 pooled standard deviations (cell G1). Scientists who reported stronger feelings about the regularity of incidents of subtle racism than did students in our survey, at the same time indicated a statistically smaller degree of *Alignment* with the scientific community (cell B4) than did their student counterparts (cell D4). However, note that this discrepancy in *Alignment* has a smaller practical significance of .259 (cell G4). Nonetheless, these two statistically significant discrepancies between Black Scientists and students hint at a possible inverse relationship between *Alignment* and *Microaggressions* in the science pipeline. Could we suggest that inbecoming a Black Scientist, one is likely to experience feelings of a lack of cultural alignment and regular experiences with subtle forms of racism? Although rhetorical in nature, the results of the t-test suggested that these two constructs were the best measure of the difference between our participating groups.

This finding emerged as intriguing given the nature of the results and the assumed demographic makeup of our population. Although the scientists reported experiencing feelings of subtle forms of racism, or *Microaggressions*, they also reported feeling less aligned with the community despite being scientists. By contrast, the students were more likely to express feelings of alignment with the science community and were less likely to report experiencing *Microaggressions*. Given the current pipeline issues for future Black Scientists, one would assume students would be less likely to feel aligned with the community of science, but our early indications suggested the opposite. As a result, we must question how the science community produces feelings of being culturally mismatched for students of color.

5.3 Analysis 3: Hierarchical Linear Regression

The factor analysis allowed this study, which began as essentially a collection of dependent variables, to explore possible underlying factors that help explain the variance in subject responses. As t-tests among these factors suggest a possible inverse relationship between *Alignment* and *Microaggressions*, we began to speculate that the degree of the feelings of alignment might be partially explained by experiences with *Microaggressions*. Could experiencing *Microaggressions* make scientists feel a sense of cultural mismatch or misalignment? Additionally, were these experiences similar for Black men and Black women? We conducted linear regression analyses to compare gender (and other possible associations) with the degree of survey respondents' identification with their scientific communities.

Table 3. Results of the series of hierarchical linear models predicting expertise overtime

		A	B	C	D	E	F	G	H	I	J	K	L
1	**Predictor Variable**	B	SE B	β	Adj. R^2	B	SE B	β	Adj. R^2	B	SE B	β	Adj. R^2
2	Intercept	7.555***	.983		.039***	9.229***	1.0.		.090***	3.723***	1.13		.239***
	Demographic Predictors												
3	Student?	.839***	.243	.154***		.590*	.241	.108*		.765***	.226	.140***	
4	Female?	.795**	.249	-.145**		-.689**	.243	-.126**		-.727	.225	-.133***	
5	High School GPA?	-.350	.278	1.057		-.419	.271	-.068		-.361	.252	-.059	
	Theoretical Predictors												
6	Microaggression					-.157	0.29	-.235		-.079**	.030		-.119***
7	Achievement Ideology									.109	.037		.120**
8	Cultural Inversion									.164	.067		.100*
9	Fictive Kinship									.121**	.043		.118**
10	Engagement									.459***	.054		.367***

Table 3 summarizes three hierarchical regressions on *Alignment* as the dependent variable. In the first regression step, represented by columns A-D, demographic predictor variables were entered into the regression equation. These demographic predictors allowed us to control subsequent regressions for whether or not a respondent was a student (i.e., status), whether female or not (i.e. gender), and for their high school GPA. This analysis helped us highlight which factor had the greatest influence on a participant's responses. As referenced in cell D2, the R-squared value indicates that a linear combination of these control variables explains only 3.9% of the observed variance in *Alignment*. Also note that while the standardized regression coefficients on status and gender (cells C3 and C4, respectively) are statistically significant, the coefficient on high school GPA (cell C5) is not. This suggests that the academic preparation of the student prior to their science major is not a significant factor in their feelings of alignment. This would also suggest that students from Ivy League institutions to students attending junior colleges and state colleges are susceptible to the same issues of disenfranchisement. Hence there is both a status and a gender effect on *Alignment*, but not an effect based on high school academic performance that frames these differences. From cell C3 we see that while controlling for both gender and high school GPA, student respondents, on average, report a .154 standard deviation increase in *Alignment* over their Black Scientist counterparts. In cell C4 we see that while controlling for both status and high school GPA, female respondents, on average, report a .145 standard deviation decrease in *Alignment* over their male counterparts. These results confirm a long held assumption that being a part of the science community is more difficult for Black women than for Black men.

Microaggressions, which demonstrated an inverse relationship with *Alignment* in Table 2, was next entered as a predictor into a second regression step that controlled for status, gender, and high school GPA. Controlling for these demographic predictors resulted in a one standard deviation increase in the level of *Microaggressions* experienced by a respondent associated with, on average, a .235 standard deviation decrease in their *Alignment* score. The more an individual experienced *Microaggressions*, the less likely they were to feel aligned with the community in which they participated. This is an important finding given the t-test results that indicated that Black students were more likely to report feeling aligned with the community, while Black Scientists were more likely to report experiences with racial *Microaggressions*. Meanwhile, both the status as student or scientist (cell

G3) and gender effects (cell G4) remain statistically significant. The adjusted R-squared value (cell H2) indicates that the linear combination of predictors in this second regression step now accounted for 9.0% of the observed variance in *Alignment*. This was a statistically significant improvement over the adjusted R-squared value reported for the first regression step (cell D2).

With the explained variation in *Alignment* still below 10%, we performed a third regression step in which the remaining composite variables were entered in addition to the demographic and Microaggression predictors. The result was a statistically significant increase over the second hierarchical step in explaining the variation in respondents'*Alignment* scores. This third step, as indicated by the adjusted R-squared value in cell L2, accounts for 23.9% of the explained variation in *Alignment*. Note that throughout column K of Table 4, all of the standardized coefficients, with the exception of high school GPA, are statistically significant. This includes the remaining presence of both a status and gender effect, in addition to a continued negative coefficient on *Microaggressions*. The standardized coefficients on *Achievement Ideology*, *Cultural Inversion*, *Fictive Kinship*, and *Engagement* are all positive. Of these additional predictors added to step three of the hierarchical regression, *Engagement* appears to have the strongest association on *Alignment*. This result is quite intriguing, suggesting that as an individual is more strongly aligned with the community, they also experience greater engagement with the community. Those individuals who share common cultural practices and norms with the science community would be more likely to remain engaged with the practices of that community.When controlling for all other predictors, a one standard deviation increase in the level of *Engagement* perceived by a respondent associated with, on average, a .367 standard deviation increase in their *Alignment* score.As a result, the findings indicate the need to pay close attention to how individuals' participation in a community can enhance or inhibit their roles as members. The results of this analysis led to an additional exploration of the role of *Engagement* as a predictor.

Table 4. Pearson intercorrelations among composite variables

		A	B	C	D	E	F
	Composite Variable	**Micro-aggressions**	**Achievement Ideology**	**Cultural Inversion**	**Align-ment**	**Fictive Kinship**	**Engagement**
1	**Microaggressions**	1	-.117	.159*	-.258*	.222*	-.371*
2	**Achievement Ideology**	---	1	.035	.134*	-.070	.042
3	**Cultural Inversion**	---	---	1	.051	.066	-.050
4	**Alignment**	---	---	---	1	.003	.380*
5	**Fictive Kinship**	---	---	---	---	1	-.210*
6	**Engagement**	---	---	---	---	---	1

*(2-tailed) *p<.03*

5.3.1 Engagement

It is worth noting that while the standardized coefficient on *Microaggressions* remained statistically significant in our third and final hierarchical step, its magnitude was nearly cut in half when including the remaining composite variables as predictors. This result highlights how *Microaggressions* may be best explained by how other factors shape an individual's experience. Table 4 may help explain this biasing of the association between *Microaggressions* and *Alignment* in the second regression step. Pearson intercorrelations were performed between all six composite variables. As computation of this matrix entails a family of 15 2-tailed tests of significance, in order to reject the null hypothesis that population correlations between variables are zero, a conservative Bonferroni adjustment for the increased probability of Type I error amongst this family of 15 tests requires a p-value of less than *alpha/number of tests = .05/15 ~ .003*. With only correlations surviving the Bonferroni correction flagged, it can be seen that the two strongest statistically significant correlations are between *Alignment* and *Engagement* (r = .380; cell F4) and *Microaggressions* and *Engagement* (r = -.371; cell F1). It follows that high *Microaggression* scores tend to go with low *Engagement* scores, while low *Engagement* scores tend to go with low *Alignment* scores. That would suggest that as one in engaged in the science community, an experience with *Microaggressions* would lead an individual to disengage with the community and to experience feelings of misalignment. If we take this result on its merit, then providing Black students with experiences that support their cultural identity should promote *Engagement* and *Alignment* and reduce the prevalence of *Microaggressions*. Hence when we examined the association between *Alignment* and

Microaggressions in the second step of our hierarchical regression, omitting the *Engagement* composite variable biased the standardized coefficient on *Microaggressions* downward; part of the negative association between *Microaggressions* and *Alignment* actually resulted from the propensity of respondents to report lower *Engagement* when experiencing greater numbers of *Microaggressions*, and this lower *Engagement* in turn decreased the degree to which respondents report being aligned with the scientific communities in which they practice or major.

Given our primary research question's initial goal of examining what theoretical perspectives on race served as primary explanations of the difference between students' and scientists' experiences, Wenger's (1998*in Lit. Cited it is 1999*) notions of *Alignment* and *Engagement* emerged as the most useful indicators of the difference between students' and scientists' experiences. Although our initial analyses pointed towards the role of *Microaggressions* (1998) as a key indicator and predictor of potential pipeline differences, our subsequent analysis suggested that the *Microaggressions* scale was best explained as a result of two other theoretical constructs; *Engagement* and *Alignment*. Ultimately the matrix of analyses conducted here pointed to the challenges of building a science pipelines for African-Americans. Scientists and potential science majors must manage feelings of cultural alignment, which according to our analysis will be a predictor of *Engagement* and experiences with *Microaggressions*. Conversely, programs must consider how to mediate these experiences in the hope of helping students obtain full access to the community of science throughout their K-University science experience.

6. Implications

The implications of the results of this research project take us back to our research questions. First, in reflecting on the variety of theories of participatory structure that explain how race, when enacted in participation, can play a role in access to science, two theoretical positions emerged. Both the notion of *Microaggressions* and *Alignment*/*Engagement* provided intriguing insights about our participants' perceptions of their science experiences. What may be most useful in future studies is the manner in which these theoretical constructs impact each other, and how the experiences of Blacks in science and pursuing science careers result from these intertwined theoretical relationships.

Although race has remained central to explanations of the science pipeline dilemma for African-Americans, research has done little to offer an explanation of why and how race plays a role in fueling pipeline challenges. Our initial discussion of the colloquial "Black Tax" that has been discussed in African-American communities was tenuously confirmed as we highlighted how differing levels of *Engagement* and alignment can predict *Microaggressions* and vice-versa. The results are valuable in their ability to highlight how subtle forms of racism (*Microaggressions*) may limit the extent to which Blacks can feel like full members of the science community. As a result, those who are able to matriculate through the system must do so at a cost. This finding challenges the very nature of the notion of equity. If we consider representation as equity, we may never truly understand how the culture of a community of professional and academic practice may hinder full access.

This point is further exasperated by the inverse nature of the Black Science majors' responses. Given their stronger feelings of alignment and decreased emphasis on racial interactions, one could deduce that race is less significant for them. This is an intriguing result given the disproportionate number of Black Scientists who graduate from Historically Black Colleges and Universities. The results of this study lead us to further hypothesize that a large percentage of our population were students attending HBCUs, and thus, experienced greater alignment and less *Microaggressions*.

If this were indeed the case, then how would these experiences compare to students from traditionally white universities? The scope of this study does not allow us to address this query empirically, but does provide us with an empirical basis from which to explore that conception.

A final series of implications that emerge from these findings involve the emergence of *Alignment* and *Engagement* as our most significant indicators of variability amongst our participant groups. It is clear that *Engagement* may play a significant role in how Black Scientists and students align with their particular communities of scientific practice. If individuals are allowed access to a community, but do not find opportunity to participate on equitable terms or to become valued contributors, their sense of engagement is in jeopardy. More generally, how Black scientists and students align themselves with scientific communities may not be just a simple matter of whether or not they merely have *access* to these communities of practice, but rather, the degree to which these individuals actually *relate* to members of these communities may play a crucial role. This theoretical and more nuanced construct of *Engagement* may indeed have greater implications for such an enculturation process then the degree to which subtle acts of racism are perceived. Given this finding, this

study hopes to encourage greater research into the specific interactions of people of color in science communities at both the university and professional levels.

6.1 Limitations of the Study

In concluding this manuscript, we would like to recognize some limitations to the study. First, the online nature of the data did not allow us to disaggregate the data based on institution type or by institution name. Given the role of cultural practices in *Engagement* and *Alignment*, such data would enable us to compare if any differences were experienced based on the nature of the institution involved, e.g. HBCUs vs. Traditionally White Institutions (TWIs). Second, given the exploratory nature of our project, the data was not capable of offering definitive explanations of what specific sources produced pipeline challenges. Rather, this study was designed to assess the relative effectiveness of a number of theories that are rarely applied to the exploration of the pipeline challenge for Blacks in science.

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Note

Note 1. Howard University (105), Florida A&M University (76), Hampton University (69), Spelman College (68), Morehouse College (63), Morgan State University (50), Southern (48), Xavier (45), North Carolina A&T (42), & Tuskegee (41)