WHAT WORKS AND WHY:
FINDINGS FROM PROJECT KNOWLEDGE

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INTRODUCTION

This is the first of a series of white papers designed to update the HBCU STEM-US Community on research findings associated with the Analytic Hub. The STEM-US Center’s Analytic Hub is a unique entity within the HBCU STEM-Undergraduate Success Center. The Hub was created to assist researchers associated with the STEM-US Center in answering the fundamental questions- “WHAT ACADEMIC INTERVENTIONS WORK AT HBCU’S AND WHY DO THEY WORK?” Now in year four, of the first five years of funding, the Center has generated some answers. This series will focus specifically on findings resulting from the collaborations between external faculty partners associated with the Analytic Hub.

As stated in the original grant proposal (Muldrow et al, 2019) the fundamental question of “WHAT ACADEMIC INTERVENTIONS WORK AT HBCU’S AND WHY” drives all aspects of the Analytic Hub’s research agenda. These fundamental questions were broken down into two separate research areas:
1. Identifying what specific types of academic interventions are effective at increasing academic performance for entering HBCU students and
2. Identifying the essential and common components that contribute to their efficacy.
These two areas of focus eventually congealed into a research rationale that examined not only efficacy but also impact and sustainability, as well as methodology.

The Hub’s research is conducted using a variety of approaches including case study, community-based participatory research and quasi-experimental research designs. Along the way, new psychometric and statistical approaches have helped to further elucidate the impact of different and distinct HBCU campus cultures on academic performance of entering STEM students. The iterative nature of the Hub’s research eventually led to the examination of the replicability and scaleability of successful intervention models, given the heterogenous nature of the HBCU student population.

This present writing aims to inform a broad range of stakeholders, from students and parents to STEM faculty and student affairs professionals about the necessary and essential components of a successful academic intervention. Because the work
continues, it is the ultimate goal to provide The Center’s partner HBCU’s with an accurate and timely profile of entering successful students on an annual basis. The goal is to produce a profile of a successful HBCU student that is generated using person-centered data analyses from a combined data repository. The data that will eventually be obtained from our various HBCU partners is based on a theoretically-derived assessment instrument customized for their institution. The theoretically-derived instrument has been in use since 2018 at Virginia State University. The assessment instrument has since been validated and revised by researchers associated with the Hub. Once implemented it will provide a description of the constellation of motivational factors leading to lasting academic success for entering students. Armed with this data, stakeholders will be better equipped to explain and even predict outcome measures associated with STEM persistence, retention and graduation at their respective institutions.

Before focusing on assessment, we sought to first address methodological issues associated with Discipline-Based Educational Research conducted at Historically Black Colleges/Universities.

THE PROBLEM WITH DBER RESEARCH AT HBCU'S

Many published studies examining HBCU students’ retention focus on psychosocial and structural factors (Garrett, L., Huang, & Carter, 2017). These factors include the use of culturally relevant practices, the supportive social environment offered by HBCUs, and the policies and procedures in place at HBCU’s that are specifically designed to mitigate issues of student under-preparedness (Garrett, Huang, & Carter, 2017; Gasman & Nguyen, 2014). HBCUs are known to value students as institutional members (Tinto, 1987); not only providing them early supports, such as summer bridge programs but also exposure to STEM careers through research-related partnerships (Garrett, Huang, & Carter, 2017; Toldson, 2017, & Gasman & Nguyen, 2014).

Yet, the characterization of Black student success is rarely accompanied in the literature by studies that do more than describe the interventions. Studies aimed at explaining and predicting what is needed for student success require hypothesis testing, model creation, and theoretical frameworks which are integral to making discipline based educational research (DBER) useful to practitioners. The limited use of psycho-social
theory, particularly, has contributed to the paucity of causal and predictive models needed for the replication of effective academic interventions.

A search of the literature using Google Scholar (Davis, 2020) was conducted using the keywords “STEM education,” “African American STEM students”, “HBCUs”, “STEM education”, and “African American STEM persistence.” From the keyword search, thirty-five of the 7770 initial studies specifically identified African American students as the targeted participant group. Among these, several were studies aimed at HBCU STEM students. The following theories were associated with their investigations: Social Cognitive Career Theory (SCCT; Lent, Brown, & Hackett, 1994) (n=2), Trilogy Model (Campbell, Jolly, & Perlman, 2004. (n=1), Nigrescence Cultural Identity Model (Cross, 1978) (n=1), Tinto’s Retention Theory (Tinto, 1994), (n=1) and Critical Race Theory (n=1). Most of the 35 identified studies did not identify or use any theory to guide their research aims. In addition to the low numbers of studies using theory to aid in the description, explanation and predictive value of their findings, the reported results were sometimes contradictory or reported inconsistent conclusions. These methodological shortcomings encouraged generalization without conclusive evidence.

Another methodological practice that hinders the replication and scaling of impactful DBER research at HBCUS is the comparison of HBCU students to African American students attending predominantly white institutions. These studies are thought by some to amplify minority student failure and deficits instead of their achievement (Harper 2010; Spencer, 2018).

Finally, DBER studies featuring HBCU’s are not likely to take advantage of more sophisticated psychometric techniques that require larger data sets. The relatively smaller student populations at HBCU’s make it difficult to recruit hundreds of incoming STEM students, for example to include in a research study. This limitation contributes to the characterization of African American students or HBCU students as a homogenous sample/participant group. This characterization occurs despite the fact that the nearly 100 HBCU’s offer unique educational experiences that are distinct from one another in a number of significant ways (Muldrow, Mason and Boyd, 2019).

In an effort to rectify these methodological shortcomings, the following practices were considered integral to the research associated with the Analytic Hub:
1. The use of theory and hypothesis testing that examines student performance as measured by student grades or other indicators of academic behavior change.

2. Mixed method data collection that examines contextual factors associated with the entire learning (and teaching) ecosystem

3. Multi-institutional data sets that allow for the use of person-centered statistical analysis and help characterize the multi-dimensional nature of a successful HBCU student.

In this series, the results of each of these practices will be addressed in turn. The purpose of this present work is to describe how the use of theory has contributed to the broad scope of the research conducted by the Analytic Hub.

We begin by describing the research behind Project Knowledge, an academic intervention conducted at Virginia State University and continually funded by NSF since 2014. Project Knowledge used near-peer mentoring to identify the critical and essential factors associated with an effective intervention model. The goal of the intervention was not to replicate the proven effectiveness of mentoring but to test the usefulness of a psycho-social theory in identifying the most essential characteristics of the intervention. As part of the Hub’s research plan, the ultimate goal was to replicate the results at another institution and to then attempt to scale the successful effort. This goal has not yet been realized. However, the impact of Project Knowledge has now spread to other student-facing entities across the Virginia State University campus and has been featured in a blog sponsored by NSF IUSE (2024). Additionally, the high school version of Project Knowledge has been the target of replication efforts in another state, fueled by dissemination efforts that highlighted it’s efficacy (Futurum, 2022).

Subsequent reports will highlight the methodological innovations that were enhanced by the theory-derived approach. This includes how the need for contextual data led to innovative methodological approaches (ie psychometric networks) and the novel use of broader theoretical frameworks (Representative Design and Active Inference). The final report will detail the identification of one critical protective factor associated with early retention of HBCU STEM students, “locus parentis.” This important finding led to the
The recent proposal of “FREE/STEM: Forwarding Racial Equity and Engagement in STEM” that highlights HBCU faculty development. Once funded this, $5M research effort will feature a collaboration of 7 institutions and cover research in Psychometrics as well as DBER research. **The FREE/STEM research effort is one of the most significant research outcomes to emerge from the HBCU STEM-Undergraduate Research Center** and is a direct result of the trans-disciplinary collaborations fostered within the Analytic Hub.

**PK: AN INTERVENTION AND RESEARCH PROJECT**

A significant portion of entering HBCU STEM students enter college with less than optimal preparation for introductory STEM courses. The reasons for this are varied but includes complex structures and social positionality that impacts marginalized groups. While the interconnected systems (social, economic and political) may have influenced a student’s prior educational experience, educational research on interventions usually do not include such broad reach within the scope of the research. This is one reason that the American Psychological Association’s Taskforce on Resilience of African American Children and Adolescents (2008) recommended one theory Spencers’ Phenomenological Variant of Ecological Systems Theory (PVEST) ate help guide future research.

The Task Force reported that research on student resilience should consider how Black children exposed to stressful events display adaptive or maladaptive behavior in a school setting. However, the report also recognized the difficulty in assessing resilience as a psychological construct. As a developmental and ecological theory, PVEST considered the social, historical and cultural influences on the normative development of African American youth. By focusing on the the relationship between coping and vulnerability, PVEST provided a non-deficit approach to examining identity development in minoritized student populations.

**PROJECT KNOWLEDGE: ACADEMiC INTERVENTION**

PVEST was used a guiding theory in the conceptualization, implementation and interpretation of data from Project Knowledge. For the intervention, Identity development was associated with matriculation as a student progressed from entry level to third year students. Resilience was operationalized as an outcome measures associated with
student performance that allowed students to remain at the institution and enter the STEM major. “Academic performance” was defined broadly and included lag measures, such as course and semester grades and also lead measures such as class attendance, time management and self-advocacy. The lead measure activities, used to produce lasting academic behavior change, were hypothesized as being transferred through academic mentors. Therefore the intervention did not directly address subject matter content but rather focused on motivation and affective factors associated with learning.

As stated above, Project Knowledge has two identities both as a research project and as an effective academic intervention. The goal of Project Knowledge as an academic intervention was to use highly trained near-peer mentoring to provide experiences that first associated positive affect (i.e. feelings of self-confidence, self-agency) with schoolwork. In addition, the intervention sought to diminish negative feelings that may already be associated with previous academic experiences. It was hypothesized that strong relational bonds would serve as a protective factor for school related vulnerabilities experienced by the mentees. With the help of the near-peer mentors, the mentees would then be primed to adopt new attitudes, beliefs and behaviors that would help them to maintain sound academic habits once the intervention ended.

Project Knowledge as Academic Intervention- Theory of Change
PROJECT KNOWLEDGE: RESEARCH PROJECT

The initial goal of Project Knowledge as a research project was to identify the most effective and efficient ways to support the transfer of skills from mentor to mentee. This was done by using PVEST to understand the role of specific components of the intervention in terms of a student’s progression toward academic identity formation, which was operationalized as the use of academic behaviors needed to matriculate.

The difference between the intervention and research project aspects of Project Knowledge makes it difficult for one illustration to accurately depict the results. Project Knowledge as an academic intervention can be illustrated as a logic model or theory of change because the short and long term outcomes were known. The logical progression from the participant samples to the activities that would most likely achieve the outcomes were obtained from previous literature and best practices. Where as, Project Knowledge as the research project was iterative by design and the majority of the outcomes were not known. However, the Research Rationale did require a logical progression of questions and answers which began as a series of IF/THEN statements.

- IF Academic intervention seeks to increase STEM retention at the institution and graduation from the institution THEN what is needed is improved academic performance as measured by GPA

- IF GPA improvement is needed for retention and graduation in STEM THEN students must have acceptable GPA to enter major in junior year.

- IF students are going to have acceptable GPA in junior year THEN students must have successfully navigated introductory courses during freshman and sophomore years.

- IF students are to successfully navigate mandatory introductory STEM course during first four semesters THEN students must employ academic practices that produce successful grades for first four semesters
• IF students employ sound academic practices for first four semesters THEN they must understand what those practices are and be motivated to utilize and maintain them.

Several studies from the Talley Lab have shown the usefulness of PVEST as a theory in determining intervention strategies. In numerous dissertations and theses, the theory has helped elucidate the role of Self-Regulation, Self Efficacy, Self-Confidence and Self Agency. These findings have contributed to the iterative nature of the Project Knowledge research and have led to the following conclusions regarding the essential components of an effective academic intervention. Based on PK, an effective academic intervention builds academic skills in an emotionally-safe space; nurtures self-confidence; encourages self-efficacy; promotes self-agency and initially may provides extrinsic motivation until intrinsic motivation is firmly established. These conclusions were based on the following observations.

1. It was easier for students to change their academic habits in a safe and supportive community. Hence the relational bonding with their mentor and co-mentees was essential in fostering self-confidence.
2. Early and invasive monitoring was critical to addressing academic issues long before they were recognized problems at the assessment level. In other words, mentors were alerted to behaviors that could threaten academic performance before grades were impacted.

3. As students consistently experienced small successes, it was crucial to maintain the behaviors through recognition and affirmation within the community (extrinsic motivation). Students were more prone to adopt the rewarded behaviors for use in other contexts not associated with the intervention (self-efficacy).

4. As self-confidence and self-efficacy grew, mentees recognized their newly attained skills as their own and not that of the mentors (intrinsic motivation).

5. By the end of the first year, students were no longer involved in a formal intervention and felt prepared enough to be a mentor to other students (self-agency).

CONCLUSIONS

The research findings from Project Knowledge also suggested that the progression to self-agentic behavior could be spurred through other means and not just from a near-peer mentor. A supportive relationship with a teacher or advisor could lead to lasting academic behavior change in a student, given enough time and monitoring. However, the mentoring stream model has the advantage of being scalable and has the potential of reaching many more students than one-on-one counseling/advising.

There were two other significant research products of the Project Knowledge investigations. The first significant output was the creation of a PVEST inspired assessment instrument (Scherer, Fife and Talley, 2017). The story of that instrument’s development into the STEM-US Quantitative Assessment Instrument will be the focus of the next White Paper. The other significant outcome was the discovery of “constellations” of protective factors that appear to work collectively to mitigate the
effects of pre-existing risk factors and the situational stressors that are a natural part of the college experience. **Mitigation of these risk factors through a trusted teacher relationship, primarily with African American female STEM instructors** became the focus of a separate line of investigation. The FREE/STEM initiative will be the focus of the third White Paper in this series.

All of the findings reported here support the use of PVEST as a foundational research theory in the conceptualization, implementation and interpretation of Discipline-Based Educational Research at an HBCU.