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HBCU STEM UNDERGRADUATE SUCCESS RESEARCH CENTER ANALYTIC HUB BLACK PAPER #001

WHY IT WORKS:

FINDINGS FROM PROJECT KNOWLEDGE-

A 10 YEAR ACADEMIC INTERVENTION STUDY

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INTRODUCTION

This is the second in a series of papers intended to update the HBCU STEM-US Community on research findings associated with the Analytic Hub. You have heard of White Papers, which are defined as a brief publication that succinctly explains or describes a narrow topic. We have coined the term "Black Papers "to describe something else- a source document that covers many topics and provides the broader context from which multiple related White Papers and other works will come. Just as light comes out of darkness and seedling emerges from soil knowledge comes first from unknowing. Telling a story in which the ending may not be conclusive is the purpose of a Black Paper.

Although this writing will document scientific findings, it is not meant to be a manuscript. The writing tense is not in the passive third person but is in a plural active voice. This better reflects the intention of people who are actively contributing to a body of work meant to better understand other human beings. Additionally, since text has been gathered from multiple original sources, there is no consolidated reference list. However, a comprehensive bibliography is being developed and will be available to those who sign up at the Hub's website www.HBCUSTEMhub.org.

This Black Paper series will focus specifically on findings resulting from the collaborations established by the Analytic Hub, the outward facing research arm of the HBCU STEM-Undergraduate Success Research Center. Ultimately, this body of work aims to support an increasing number of communities of practice that focus on Discipline Based Educational Research at HBCU's. The Analytic Hub is a unique entity within the HBCU STEM-Undergraduate Success Research Center. The Analytic 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 Hub has generated some answers. The normal route would be to disseminate this information through peer-reviewed manuscripts. This is also our plan but in order to better inform our community we chose to present the information in a different way. We wish to tell our story, starting here.

As stated in the original grant proposal (Muldrow et al , 2019) the fundamental question of "WHAT ACADEMIC INTERVENTIONS WORK AT HISTORICALLY BLACK COLLEGES/ UNIVERSITIES (HBCUs) AND WHY" drives all aspects of the Analytic Hub's research agenda. The fundamental research 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.

Early in the project, we surveyed the literature of successful intervention efforts to ascertain WHAT interventions work at HBUC's. We learned that many, if not all of the publications reported positive results. We concluded that a **variety of programs, like intrusive advising, mentoring, summer bridge programs, interest enhancement and immersion models all can produce positive effects** when given enough money and resources for a limited period of time. The real problem lies in replication, scaling and sustainability of those successful efforts. A lasting impact requires embedding aspects of the project into the. Institutional culture so that after the research has been completed and the external funding ends the positive results continue. Based on the review, we decided to focus on what successful but disparate intervention methods all have in common...we focused on WHY they work.

We conduct the Hub's research 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 the experience 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. In essence we want to know

WHY successful interventions work; WHEN do they work, with WHOM and WHERE do they work best. Because the work continues, it is the ultimate goal to provide the Center's partner HBCU's with an accurate and timely profile of successful students on an annual basis. The goal is to produce a profile of a successful HBCU STEM student using a variety of psychometric tools. One plan includes analysis from a multi-institutional data repository that enables the use of person-centered data analyses. The data that will eventually be obtained from our various HBCU partners is based on a theoretically-derived assessment instrument customized for their institution. A prototype of the 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 Analytic 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.

Granted, the goal to create a multi-institutional data repository is an ambitious plan. However, work towards that goal have begun. Details of the development of the STEM-US Assessment will be the focus of Black Paper #2 *"Strength in Numbers: Psychometrics of the STEM-US Quantitative Assessment"* We sought to set the stage here by first addressing the broader topic of Discipline-Based Educational Research. Our DBER demonstration project was conducted at Virginia State University and is known as, Project Knowledge. Ultimately, the research with Project Knowledge led us to conclude that different intervention methods all could lead to academic behavior change in a student by improving a student's beliefs and attitudes about themselves. What exactly were those beliefs and how to change them became the focus of Project Knowledge using near-peer mentoring as the intervention model.

STRENGTHENING 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 such as the supportive social environment offered by HBCUs. In addition there are 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 with 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 of the results 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 conceptually related to those examining race-related learning disparities or the "learning-gap" in the K-12 space. Such comparison studies are thought by some to amplify minority student failure and deficits instead of their achievements (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. In fact, the STEM-US Center seeks to currently capture more information on the unique character of HBCUs through the THRIVE survey. (Muldrow, Mason and Byrd, 2019; www.thriveinchbcu.org)

In an effort to rectify these methodological shortcomings, we considered the following practices 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 in a particular setting.

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, we report on the progress toward these research goals. We begin by describing the research behind the DBER demonstration effort we call "Project Knowledge" or "PK" which is 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 pscycho-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 DUE (Talley, 2024). Additionally, the high school version of Project Knowledge has

been the target of a replication effort in conjunction with North Carolina A&T University (Futurum, 2022).

Black Paper #2 will highlight the methodological innovations that were enhanced by the theory-derived approach. That report will show how contextual data led to innovative methodological approaches, such as the use of exploratory psychometric networks and Bayesian analysis. All told, the work of the Analytic Hub lays the foundation for significantly expanding the breadth and scope of DBER research. By coupling large data sets of information from HBCU's with investigatory frameworks such as Representative Design and Active Inference, the stage is set to bring DBER to the Information Age.

Black Paper #3 will detail the implications of one critical protective factor associated with early retention of HBCU STEM students, the "locus parentis"; the role of African American female faculty members on student success. This important finding led to a recent grant proposal, "FREE/STEM: Forwarding Racial Equity and Engagement in STEM." The proposal asserts that relationships between students and HBCU faculty, particularly African American female faculty, aid in helping students self-identify as successful. This important aspect of early retention efforts may not be fully recognized or adequately rewarded outside of formal interventions. The proposed research seeks to also investigate how such added responsibilities may negatively impact the scholarly productivity of African American female faculty. Once funded this, $5M research effort will feature a collaboration of 7 institutions and include research in Psychometrics, Bioinformatics, systems engineering 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 defining of "Center-ness" as practiced within the Analytic Hub.

PK: AN INTERVENTION AND RESEARCH PROJECT

One reason that the effect of a "locus parentis" is so important is because a significant portion of entering HBCU STEM students enter college with less than optimal preparation for introductory STEM courses. There are various factors behind the high number of entering HBCU STEM students who are nor proficient in calculus by the time they graduate form high school, for example. We know that the effects of many interconnected systems (social, economic and political) influenced a student's prior

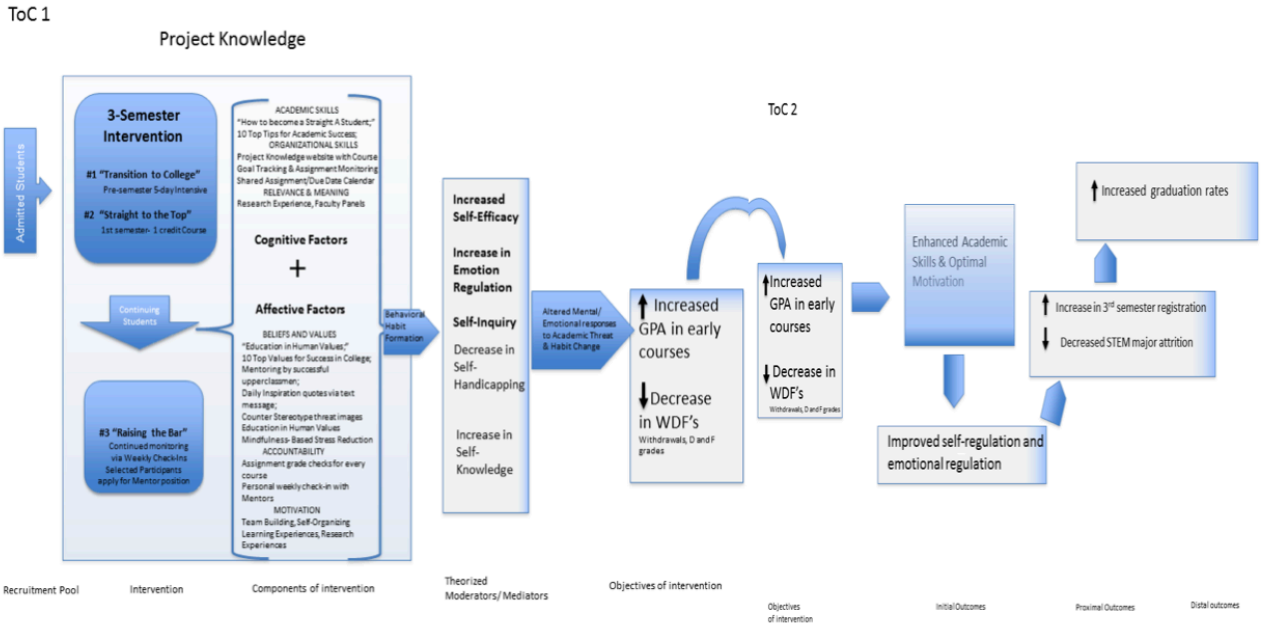
educational experience. Yet, educational researchers usually do not feature these important aspects as critical variables within the scope of the research. This is one reason that the American Psychological Association's Taskforce on Resilience of African American Children and Adolescents (APA, 2008) recommended Spencers' Phenomenological Variant of Ecological Systems Theory (PVEST) as one theory to help guide future research.

The report pointed out the tendency for research to focus on student deficits. The Task Force recommended that research on student resilience should consider how Black children exposed to stressful events in a school setting, display adaptive behaviors that support their academic performance. 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 relationship between coping and vulnerability, PVEST provided a non-deficit approach to examining identity development in minoritized student populations.

PROJECT KNOWLEDGE: ACADEMIC INTERVENTION

The goal of Project Knowledge as an academic intervention was to use highly trained near-peer mentoring to provide experiences that enabled their mentees to associate positive affect (ie. 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.

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 the first through the third semester. 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.** (Figure 1 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 knowledge and skills from mentor to mentee. PVEST helped to elucidate the role of specific components of the intervention in terms of a student's progression toward academic identity formation. A change in identity, hypothesized by PVEST, was operationalized as the continued and sustained use of new academic behaviors associated with successful matriculation.

The difference between the academic intervention and intervention research aspects of Project Knowledge makes it difficult for one logic model 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.

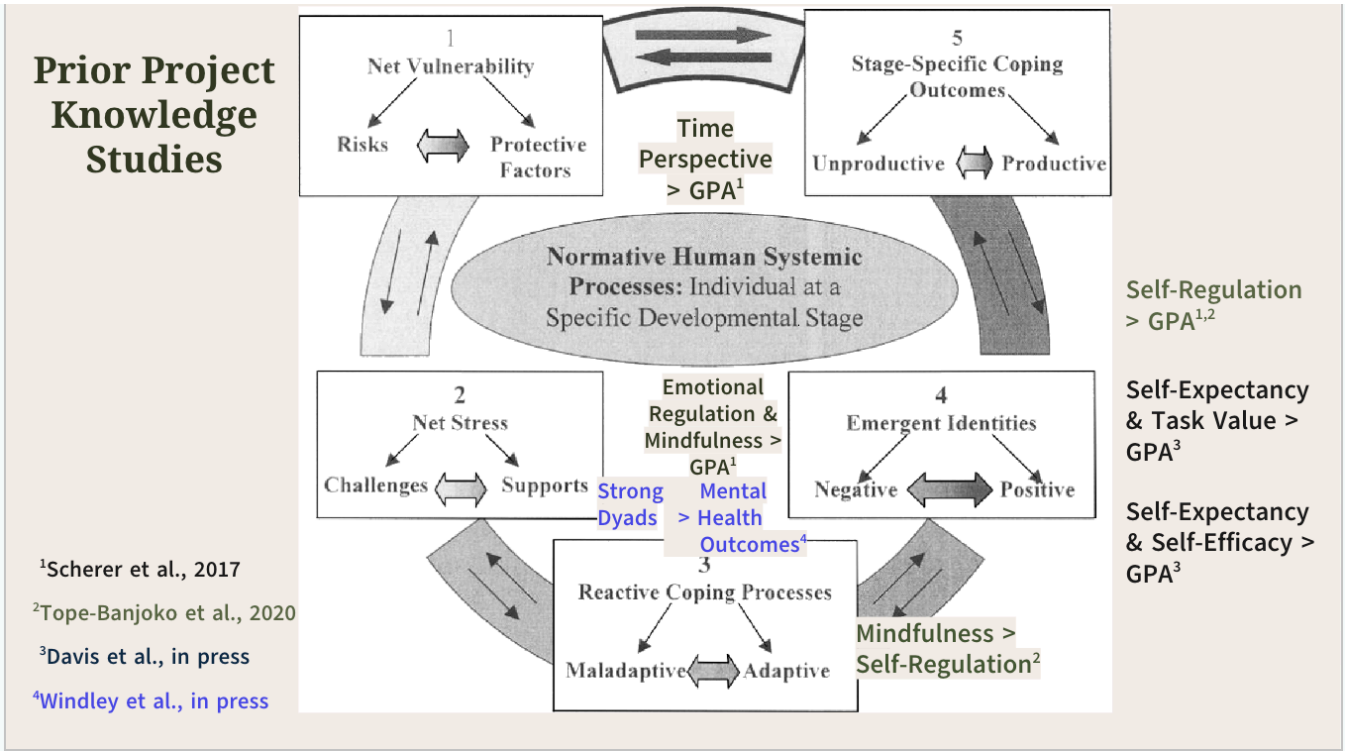
- IF Academic intervention seeks to increase STEM retention at the institution and graduation from the institution THEN what is needed is improved academic performance of student participants as measured by course grades and GPA.

- 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 freshen 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 aids in establishing intrinsic motivation for academic success.** 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 or 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 Assessment Instrument will be the focus **Black Paper #2 "*Strength in Numbers: Psychometrics of the STEM-US Quantitative Assessment.*"** 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.

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