

SCALE RADIATION-HARDENED WORKFORCE DEVELOPMENT

HBCU PILOT FOR RADIATION-HARDENED MICROELECTRONICS

FINAL REPORT

October 29, 2024

Prepared for:

**HBCU Pilot for Radiation-Hardened
Microelectronics Project Leadership**



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EXECUTIVE SUMMARY

Program and Evaluation Overview

The Historically Black Colleges and Universities (HBCU) Pilot for Radiation-Hardened Microelectronics, part of the SCALE (Scalable Asymmetric Lifecycle Engagement) initiative, addresses the demand for skilled professionals in RH microelectronics essential for military, civil, and commercial systems. Key collaborators include Purdue University for curriculum development and student conferences, Tougaloo College Research and Development Foundation (TCRDF) for recruitment and outreach, and Parallax Advanced Research for program management and internship partnerships. External evaluators have begun assessing the experiences of students, faculty, and project leaders to measure effectiveness and identify areas for improvement to support the sustainability of HBCU students in Radiation-Hardened Microelectronics careers.

Overview of Findings

- 1. Project Theory:** The HBCU Pilot for Radiation-Hardened Microelectronics (HBCU Pilot) program aims to increase representation of people of color in STEM by enhancing pathways for underrepresented students. Interest holders such as TCRDF, Purdue, and Parallax view the program differently: TCRDF emphasizes research alignment; Purdue focuses on curriculum development, while Parallax highlights national security and practical job readiness. Students appreciate how the program diversifies their academic experiences and opens doors to significant career opportunities, ultimately enhancing their confidence and readiness for roles in secure sectors.
- 2. Implementation:** The implementation of the HBCU Pilot program has encountered both opportunities and challenges. Faculty have actively recruited students, particularly from computer science and math, but face curriculum misalignment, as many liberal arts HBCUs lack engineering programs, requiring students to take extra courses. There is a need for more bottom-up creation of materials, resources, and guidance based on what is needed at HBCUs. Despite some challenges, such as a racial incident during the SURF program, students reported positive experiences, particularly valuing mentorship. Project leadership are making adjustments, including developing a core curriculum with multiple tracks and enhancing support for new faculty and students.
- 3. Effectiveness:** The effectiveness of the HBCU Pilot program varies across its key components: curriculum, internships, security clearances, and outreach. While students have gained confidence and professional skills through the program, the curriculum remains a challenge due to misalignment with the needs of liberal arts HBCUs, limiting student accessibility and recruitment. Positive feedback from Summer 2024 participants indicates a strong impact, with some expressing interest in returning. Additionally, the program is addressing the lengthy security clearance process, which is crucial for careers in this field, by exploring ways to expedite it and providing guidance to students.
- 4. Outcomes:** The HBCU Pilot program has positively impacted students by enhancing their interest in research, graduate school, and technical careers. Participants reported gaining valuable research experience, developing professional skills, and building confidence, with one student noting how the program provided insights into real lab work and its applications. The

program has effectively attracted a diverse group of participants, including those from non-engineering majors and underrepresented backgrounds in STEM. However, improvements are still needed to better align the curriculum with the needs of liberal arts HBCUs, ensuring students can participate without requiring additional courses outside their majors.

5. **Communication:** Communication within the HBCU Pilot program varies among participants, revealing both strengths and challenges. Some faculty report that meetings primarily focus on curriculum adaptation, but frustrations with certain program administrators and reliance on email hinder real-time collaboration. Conversely, other faculty find the communication effective, citing responsive leadership that provides clear guidance and useful recruitment resources, facilitating smoother implementation. To improve overall communication, enhancing real-time engagement methods and addressing administrative concerns would be beneficial. The program currently integrates anti-deficit thinking by fostering supportive communication and emphasizing the potential of students from diverse backgrounds.
6. **Diversity, Equity, and Inclusion:** The HBCU Pilot program leadership prioritizes diversity, equity, and inclusion (DEI) by implementing an anti-deficit framework that highlights the strengths of underrepresented groups in STEM. While the program aims to increase representation, faculty have raised concerns about the curriculum's focus on engineering, which may limit accessibility for non-engineering majors. Project leadership acknowledge the need for ongoing improvements to ensure inclusivity, emphasizing the importance of understanding diverse student needs and encouraging feedback through surveys. This approach aims to create a more supportive environment that effectively meets the varied backgrounds and requirements of all participants.
7. **Sustainability:** Sustainability poses a significant challenge for partnerships between Predominantly White Institutions (PWIs) and Minority-Serving Institutions (MSIs) like HBCUs, as many collaborations rely heavily on grant funding, which often fails to establish lasting infrastructure. For the HBCU Pilot, institutionalizing elements such as a more inclusive curriculum is essential for long-term success, allowing the program to persist beyond grant funding and reach a broader student base. Project leaders believe that some student support services, like mentoring and professional development, may continue through existing university resources, but the overall impact will depend on securing ongoing funding. If funding expires in August 2025, the program's ability to support a larger group of students will be significantly constrained.

Recommendations

To ensure the success and sustainability of the HBCU Pilot program and to strengthen its impact across the SCALE network, several key recommendations have been identified:

1. **Address barriers to curricular integration at HBCU partner institutions.** The curriculum should be designed to be both flexible and accessible to students from diverse academic backgrounds, including those from non-engineering disciplines. Incorporating interdisciplinary approaches that allow students who attend schools with engineering adjacent programs to meaningfully participate would expand the program's reach and relevance.
2. **Work collaboratively with HBCU faculty to co-develop course content.** SCALE leadership could work collaboratively with HBCU faculty and administrators to co-develop course content that meets both the program's needs and the available resources at HBCUs. Collaboration could

also involve creating supplementary modules or courses that introduce basic engineering concepts to non-engineering students, preparing them to engage fully with the SCALE program.

3. **Expand interdisciplinary opportunities to increase student engagement.** Many students at HBCUs are studying disciplines such as biology, chemistry, and mathematics, which have potential intersections with microelectronics. Creating pathways for students in these disciplines to participate in SCALE initiatives would attract a larger student base and promote the integration of engineering principles across various academic fields.
4. **Strengthen recruitment and outreach efforts.** Partnerships with HBCU student organizations, particularly those focused on STEM, could raise awareness and promote participation in the program. Establishing ways to connect current SCALE students with potential recruits could further foster peer engagement and encourage interest in the field.
5. **Adopt a more intentional approach to the recruitment of students for the RH-pipeline program.** By actively seeking out individuals who demonstrate a genuine interest in the program, we can ensure that our efforts are focused on candidates who are truly invested in their development within the field. This strategic alignment will not only enhance the overall quality of the students but also optimize the use of time and resources, ultimately leading to more successful outcomes for both the students and the program.
6. **Collaborate to provide more structured opportunities for partnership and SCALE capacity building among leadership.** By fostering stronger connections between institutions, leaders can share best practices, resources, and strategies that promote mutual growth and sustainability to not only strengthen the network but also empower leadership to implement innovative solutions that address shared challenges, create a more cohesive framework for advancing diversity and inclusion in STEM education across all participating institutions.
7. **Continue evaluation of this project.** Finally, continuing the evaluation of the HBCU Pilot project is vital for understanding its long-term effectiveness and impact. Ongoing assessments can identify successful strategies and highlight areas for improvement, ensuring that the program adapts to the evolving needs of students and institutions. By gathering data and feedback, interest holders can make informed decisions that enhance the program's sustainability and alignment with its goals.

Conclusion

The HBCU Pilot program has made significant strides in advancing educational opportunities and access to specialized fields of microelectronics for students at HBCUs. The program has facilitated the development of new academic and mentorship pathways, helping to bridge the gap between underrepresented students and cutting-edge fields like radiation-hardened systems. However, several challenges remain, particularly around the sustainability of these efforts, the alignment of curriculum with the unique academic structures of HBCUs, and concerns with recruitment and outreach.

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INTRODUCTION

As technological advancements continue to shape our future, fostering a skilled workforce in the semiconductor industry has become increasingly vital. Emphasizing diversity within this workforce is essential, as varied perspectives enhance innovation and problem-solving in this critical field. The HBCU Pilot for Radiation-Hardened Microelectronics program is part of the Department of Defense's SCALE Initiative, led by Purdue University, and aims to address the pressing need for skilled professionals in radiation-hardened microelectronics—an area crucial for military, civil, and commercial systems. By partnering with Historically Black Colleges and Universities (HBCUs), the program engages students, providing them with specialized coursework, laboratory experiences, and hands-on summer research opportunities.

Evaluation has been integral to the SCALE Initiative since its inception. The external evaluation provides valuable insights for decision making and helps program leadership understand the connections between project rationale, activity implementation, effectiveness, outcomes, and sustainability, particularly focusing on diversity, equity, and inclusion (DEI).

Our approach treats evaluation as a reflective experience, involving data collection and dissemination that foster critical reflection on the program's effectiveness, including what works, what doesn't, and why. By adopting a collaborative, culturally responsive, and equity-focused methodology, we promote learning and enhance the utilization of evaluation findings, ensuring that the program effectively meets the needs of its participants (e.g., Boyce, 2017; Cousins, 2019; Frierson et al., 2002; Hood et al., 2015; Patton, 2012; Tovey & Archibald, 2023).

PROGRAM DESCRIPTION, BACKGROUND, AND CONTEXT

The SCALE Initiative and HBCU Pilot for Radiation-Hardened Microelectronics

The global demand for resilient, safe, and dependable microelectronics is growing due to manufacturing disruptions and a shortage of skilled workers (The White House, 2021). To address this, the Scalable Asymmetric Lifecycle Engagement (SCALE) Initiative, funded by the Department of Defense and led by Purdue University, focuses on developing the U.S. semiconductor workforce, particularly for the defense sector. By offering specialized training and educational opportunities, SCALE equips U.S. citizens with the skills needed to meet these industry challenges (Purdue University, 2023).

As part of the larger SCALE initiative, the HBCU Pilot for Radiation-Hardened Microelectronics aims to address the increasing demand for skilled professionals in radiation-hardened (RH) microelectronics, crucial for military, civil, and commercial systems. This pilot involves collaboration between several key institutions: Purdue University, responsible for curriculum development, teaching, research, and organizing student conferences; the Tougaloo College Research and Development Foundation (TCRDF), which plays a role in student recruitment, outreach, mentoring, and research, as well as supporting student conferences; and Parallax Advanced Research, a nonprofit research institute that tackles global challenges by accelerating innovation and developing technology and solutions through strategic partnerships. Parallax manages the program, facilitates security clearances, builds partnerships for internships and jobs, and expands the Connect ME program.

The pilot targets students from five TCRDF-affiliated HBCUs, offering pathways to credentials in areas such as Modeling and Simulation, Design and Intellectual Property, and Failure Analysis. The program aligns with President Biden's executive order on advancing educational equity through HBCUs by providing students with curriculum exposure, internships, security clearances, and outreach opportunities. Ultimately, it aims to engage 15% of approximately 230 eligible students, building partnerships and enhancing career opportunities in the defense sector, while equipping graduates with specialized RH microelectronics expertise.

Curriculum Exposure for Radiation-Hardened Microelectronics

The HBCU Pilot program curriculum is designed to meet the growing demand for skilled professionals in a field vital to military, civil, and commercial systems. This need is pressing due to the modernization of the nuclear triad, the expansion of the commercial space sector, and the retirement of current RH experts. The curriculum builds upon existing courses within the Purdue online program and integrates specific SCALE modules to prepare undergraduate students from Historically Black Colleges and Universities (HBCUs) through a comprehensive, three-part approach: coursework organized into multiple tracks to prepare students for this program, designing and transferring laboratory equipment, and in-person on-campus summer research experiences at current SCALE universities.

- **Coursework:** Students start with foundational courses before transitioning into specialized training across three tracks: Radiation-Hardened Modeling and Simulation, Radiation-Hardening by Design, and Test and Analysis. Cross-cutting skills are developed during the freshman and sophomore years, building on existing HBCU and Purdue Online curricula, while RH-specific knowledge, skills, and abilities (KSAs) are cultivated in the junior and senior years.
- **Laboratory equipment:** HBCU laboratories will be outfitted with specialized radiation detection and measurement tools, providing hands-on experience essential for career readiness.
- **Summer research experiences:** The 10-week summer research experience allows students to collaborate with SCALE faculty and graduate students on RH microelectronics projects. This immersive opportunity enables students to apply their knowledge in real-world settings, develop research techniques, and present their work at a student research symposium for all specialized tracks.

Developing Talent Through Internships and Career Opportunities

Internships are crucial to the HBCU Pilot program, offering students practical experience that enhance their academic training. Through partnerships with government agencies and industry, students will be matched with internship opportunities aligned with their career interests in radiation-hardened microelectronics. These internships provide a chance to develop essential skills that cannot be fully taught in the classroom, such as applying theoretical knowledge to real-world challenges and navigating professional environments. In addition to gaining technical expertise, students will have opportunities to build professional networks that can lead to future employment.

Leveraging Existing Curriculum to Support Student Security Clearances

Many careers in radiation-hardened microelectronics require a security clearance, which can often delay a new employee's productivity due to the lengthy clearance process, sometimes taking between six to eighteen months. To address this issue, the program will leverage Parallax's existing Curriculum to Leading Career (C2LC) pilot program to assist students in obtaining the necessary security clearances prior to full-time employment. This proactive approach will help students submit the required documentation for Department of Defense clearance processing while they are still in school, expediting the hiring process for positions that require clearances. By obtaining these clearances early, students will be better positioned for employment in sectors that require handling sensitive or classified information.

Enhancing Student Engagement in the HBCU Pilot Program Through Outreach

Outreach efforts are vital for engaging students and increasing participation in the HBCU Pilot program. Key activities aim to encourage enrollment, coursework completion, and credential attainment. One central component is the On-Campus Ambassador Program, where faculty at participating HBCUs promote the program and support students by collaborating with faculty, career counselors, and peer influencers to raise awareness of available opportunities. The program also includes the Visiting Technologists and Executives Program, which connects minority students with successful professionals in the field, particularly from underrepresented groups. These technologists share their experiences and provide guidance, helping students envision careers in microelectronics. Additionally, a student research conference will be hosted at Purdue University for students to present their summer research projects to potential employers. The Connect ME Portal is an essential part of the program's outreach efforts, serving as an interactive platform that connects students with educational, training, internship, and job opportunities in microelectronics. It helps students find scholarships, fellowships, and job placements while also assisting employers in identifying qualified candidates.

METHODOLOGY

Evaluation Approach, Values, and Aspirations

The evaluation team prioritizes the values of responsiveness to context, learning and improvement, and social justice with attention to equity, diversity, and inclusion as it pertains to the program's goals. As an evaluation team, we also value collaboration and co-creation, authenticity, transparency, efficiency, integrity, and usefulness. Based on our values, we strive to center the

perspectives and experiences of those from marginalized groups in STEM: women; persons with disabilities; and Black, Hispanic, and American Indian/Alaska Native individuals (NSF, 2017). Relatedly, we believe in the value of bringing attention to other marginalized voices and experiences in our work, recognizing this as a central tenet of values engagement. Ultimately, the evaluation team views their role as educative and aims to provide accurate, evidence-based information to address the evaluation questions and provide actionable recommendations.

Evaluation Design

This evaluation was conducted using qualitative methods in which we employed various data collection techniques, such as interviews and observations, to gather in-depth insights from participants. These methods allowed us to explore the experiences and perceptions of students, faculty, and project leaders involved in the HBCU Pilot program. By centering on their narratives, we sought to gather insights that enabled us to address the evaluation questions effectively. This qualitative approach yielded a rich and nuanced understanding of the program (Creswell & Plano, 2018).

The evaluation is guided by the following key Evaluation Questions:

EQ1 Project Theory: What is the shared vision of the HBCU Pilot for Radiation-Hardened Microelectronics program? How and in what ways does it vary across interest holders (TCRDF, Purdue, Parallax)?

EQ2 Implementation: What aspects of the project's activities have been implemented as planned; what opportunities, challenges, and difficulties have been encountered; and how have the project's activities been modified as a result?

EQ3 Effectiveness: How effectively are the key components (curriculum, internships, clearances, outreach) of the project operating? What is working well and for whom? What are areas for improvement?

EQ4 Outcomes: What have been the direct results of the project's activities in terms of the numbers of project participants and events, and participants' immediate outcomes related to the key components: curriculum, internships, clearances, outreach? To what extent are participants diverse (gender, ability status, ethnicity/race, geographic region, socio-economic status, etc.)?

EQ5 Communication: To what extent is effective communication and management taking place within the HBCU Pilot program (across key participants)? How and in what ways can communication and management be improved? How is anti-deficit thinking currently communicated and integrated within the HBCU Pilot program?

EQ6 DEI: How and in what ways is the HBCU Pilot program project leadership attending to diversity, equity, inclusion, and cultural issues across components (TCRDF, Purdue, Parallax)? What strategies does the project use to implement an anti-deficit framework, focusing on the strengths and potential of underrepresented groups rather than their perceived deficiencies?

EQ7 Sustainability: How and to what extent can elements of the project be institutionalized and sustained at the university or partner schools? What aspects of this project can be useful to other SCALE institution partners?

Data Collection Methods and Procedures

Data collection occurred from August 1 to September 30, 2024, and included virtual interviews with faculty, students, and project team members, a facilitated discussion with project team members, and literature reviews. The following subsections detail the specific methods and procedures implemented for each data collection approach.

Interviews

HBCU Pilot Student Interviews. Student interviews were conducted via Zoom by a member of the external evaluation team and lasted between 20 to 45 minutes. Four out of five students who participated in the SURF program in summer 2024 were interviewed, representing Savannah State University (3) and Tougaloo College (1). The semi-structured interview protocol included 10 questions covering students' backgrounds, their involvement in the SCALE HBCU Pilot program, and the application process. Students discussed the program's purpose, their experiences, challenges, and preparation for microelectronics. They also addressed diversity, equity, and inclusion in recruitment, mentoring, and cohort composition, and offered insights for future program replication. For more details, see Appendix C: HBCU Pilot Student Interview.

HBCU Faculty and On-Campus Ambassador Interviews. Semi-structured interviews were conducted with four faculty members from Tennessee State University, Savannah State University, North Carolina A&T University, and Tougaloo College. Led by a member of the external evaluation team, these interviews were held via Zoom and lasted between 30 and 60 minutes. The protocol comprised 16 questions that prompted discussions about students' backgrounds, their involvement in the SCALE HBCU Pilot program, and the application process. Faculty members also addressed the program's purpose: their experiences, challenges, and preparation for microelectronics; emphasizing diversity, equity, and inclusion in recruitment; mentoring; and cohort composition. Additionally, insights for future program replication were collected. For more details, see Appendix D: HBCU Pilot for Radiation-Hardened Faculty Interview Protocol.

HBCU Pilot Program Leadership Interviews. Program leadership interviews were conducted asynchronously online using Voiceform, a platform that facilitates audio-based interviews. Six members of the project leadership team, representing Purdue University, Parallax Advanced Research, and the Tougaloo College Research and Development Foundation (TCRDF), were invited to participate, with three providing responses. The interviews aimed to gather insights into their experiences with the SCALE HBCU Pilot program, including its goals, successes, challenges, and strategies for sustainability.

Additionally, the evaluation team met one TCRDF participant virtually via Zoom to learn more about the pilot program using the interview protocol to guide the conversation. As a result, this individual did not complete the asynchronous interview. For both the asynchronous and virtual interview protocols, see Appendix E: SCALE HBCU Pilot Project Leaders Interview Protocol.

Logic Model Focus Group

On September 23, 2024, the external evaluation team met with three project leaders from the HBCU Pilot program during their weekly meeting. The discussion lasted approximately 30 minutes and aimed to gather insights from project leaders representing Purdue, TCRDF, and Parallax regarding the program's logic and theory. Using a logic model developed by the evaluation team, we posed

targeted questions to understand their perspectives on the core purpose, key goals, and impacts of the SCALE HBCU Pilot program.

We explored their views on which outcomes are most critical for the program's success and identified activities within the logic model that they believe will significantly contribute to achieving those outcomes. Additionally, we sought their reflections on how well the logic model aligns with the program's commitment to diversity, equity, and inclusion (DEI) and discussed potential changes or priorities for refining the program in the upcoming year. This dialogue aimed to ensure that our understanding of the program aligned with their insights and to identify areas for improvement in the logic model (see Appendix A).

Literature Reviews

Two literature reviews were conducted to inform the evaluation of the HBCU Pilot program. The first review focused on the process of security clearances for students, aiming to understand the implementation process and the challenges involved. This review primarily used Engineering Village and ProQuest, a search and discovery platform for several research databases. Some of those databases include Compendex, a bibliographic database that indexes and abstracts engineering journals, conferences, reports, dissertations, standards, books, and preprints; Knovel, a database that contains engineering and science handbooks in full text, including properties, formulas, and equations; and USPTO, a database that includes 18.8 million patents dating from 1790 to the present. During its research, the evaluation team accessed the following types of resources: journal citations, indexed and evaluated websites, technical engineering information, product information, and peer-reviewed articles addressing standards and reliable data using a variety of search, analytics, and navigation tools, including full-text linking. In all, 687 subject areas were categorized using over 1200 concepts. Plus, searches were conducted using key terms that focus on government or security clearance or background checks and process, but college students and semiconductors gave no results. Two results were obtained once key terms were limited to background checks, process, and college students. The two results showed articles within the reference listing that helped provide additional literature and a pathway to guide the program's approach to facilitating security clearances for participants. This review sought to identify best practices and common obstacles educational institutions face when assisting students in obtaining the necessary clearances for employment in the defense sector. Still, the lack of findings on the topic may be best addressed by exploring faculty and administration about the program's security procedures and gathering information on the students within the program to share their experience in obtaining security clearances. This idea will give more insight into the success and challenges of security clearance within the program and add to the academic literature platform in the future.

The second literature review centered on partnerships with Historically Black Colleges and Universities (HBCUs). This review explored how relationships between HBCUs and external organizations are established, maintained, and leveraged for mutual benefit. It aimed to identify key factors that contribute to successful partnerships and how resources and assets are utilized within these collaborations. This review was conducted across several research databases, and literature was narrowed down using key terms that focused on STEM partnerships between predominantly white institutions (PWIs) and HBCUs and Minority Serving Institutions (MSIs). After narrowing the search, 47 peer reviewed articles, book chapters, and reports were identified. By synthesizing findings from these studies and reports, this review provided a comprehensive understanding of the dynamics involved in HBCU partnerships, which are crucial for the ongoing success and sustainability of the SCALE HBCU Pilot program.

FINDINGS

Project Theory

❖ **Evaluation Question #1. Project Theory:** *What is the shared vision of the HBCU Pilot for Radiation-Hardened Microelectronics program? How and in what ways does it vary across interest holders (TCRDF, Purdue, Parallax)?*

Finding #1: The HBCU Pilot program aims to increase representation of people of color in STEM by enhancing pathways for underrepresented students. Interest holders such as TCRDF, Purdue, and Parallax view the program differently: TCRDF emphasizes research alignment, Purdue focuses on curriculum development, while Parallax highlights national security and practical job readiness. Students appreciate how the program diversifies their academic experiences and opens doors to significant career opportunities, ultimately enhancing their confidence and readiness for roles in secure sectors.

Research on partnerships between HBCUs, Minority-Serving Institutions (MSIs), and predominantly white institutions (PWIs) highlights a shared vision of increasing the representation of people of color in STEM fields (Buck & Perry, 2021; Smith et al., 2021). This shared goal is realized by introducing new STEM pathways and resources to HBCUs which would otherwise lack access (Buck & Perry, 2021). The Radiation-Hardened Microelectronics Pilot program shares this vision by focusing on workforce development for underrepresented students in STEM. However, the program's objectives vary across different interest holders (TCRDF, Purdue, Parallax), including student exposure, research opportunities, and national security impacts.

At some institutions, faculty view the program as a supplement to their university's existing STEM offerings, allowing students to gain exposure to research opportunities and be acknowledged by other institutions. They emphasize the importance of network building and exposure to job opportunities, which may encourage students to pursue graduate school. One faculty member explained:

- *I think it is a way of just supplementing the many programs that we offer for students. I think from a university perspective, I think it allows our students to be exposed or seen by other institutions as well as provide other opportunities for research for students...and then advertising that we are part of something that is leading towards a major U.S. initiative.*

At other institutions, faculty see the program as a platform for advancing research in microelectronics, particularly in fields like space and national security. Faculty also emphasize the importance of getting students onboard with opportunities they would not have otherwise had access to, highlighting the creativity and potential of their students. Students echo this sentiment, viewing the program as a means of diversifying their academic portfolio and potentially transitioning to graduate school. When explaining their motivation for joining SCALE, a student described:

- *I thought it would be a good opportunity to diversify my portfolio because the program I applied to, SURF, is technically for engineering majors, and I'm not an engineering major. But I thought it would be a good opportunity, especially since they were looking for HBCUs.*

For other students, the focus is more on the practical benefits of the program. They appreciate how the SCALE program connects them to job opportunities in the defense sector and provides them with research experience. They also find the program impressive to include on their resumes and valuable in building confidence for intimidating career paths. A student explained:

- *I think that its purpose is to get students in the door of jobs that would probably be intimidating, like working with the government in highly secure areas. I think that can be kind of intimidating for people just getting out of college, or people still in college trying to do internships, but they made it very accessible to a wide range of students.*

A leader from Parallax, a key collaborator in the program, highlighted the tailored curriculum designed to equip students with critical knowledge and skills relevant to both students and potential employers. The leader highlighted that the program focuses on exposing HBCU students to microelectronics, particularly radiation-hardened technologies, through a structured two-year program. The leader explained:

- *To expose HBCU students to microelectronics, particularly radiation-hardened microelectronics and provide them with knowledge and skills that are desired by potential employers. This is currently a two-year program. The first semester is primarily focused on establishing criteria for earning the certificates, selecting coursework that would develop relevant knowledge and skills, and generating recruiting materials for schools and students. The second semester is primarily focused on recruiting schools and students and launching the Visiting Technologists and Executive (VTE) series to inform and inspire the students. The summer is devoted to undergraduate research at Purdue under the SURF program. This academic year, the focus will be recruiting approximately 30 students and launching the coursework, both on-line and at the home campuses. We anticipate awarding our first certificates at the end of next summer.*

A leader from Purdue, the lead organization in the partnership, outlined the program's goals to provide domestic graduates with a strong foundation in radiation-hardened microelectronics. Key efforts include continued recruitment of faculty and students, advancing students through the certification process, and expanding student participation in research following the 2024 SURF program. The pilot phase runs from August 2023 to August 2025.

Though program documents, such as the SOW, which outline the roles of collaborators—with TCRDF emphasizing research alignment, Purdue focusing on curriculum development, and Parallax highlighting national security and practical job readiness—recent data collection gleaned little insight into how these organizations are collaborating in practice. Questions still linger regarding the cohesion of their efforts, the mechanisms of their partnership, and how effectively these roles are integrated to support the overall success of the program.

Implementation

❖ **Evaluation Question #2. Implementation:** *What aspects of the project's activities have been implemented as planned; what opportunities, challenges, and difficulties have been encountered; and how have the project's activities been modified as a result?*

Finding #2: The implementation of the HBCU Pilot has encountered both opportunities and challenges. Faculty have actively recruited students, particularly from computer science and math, but face curriculum misalignment, as many liberal arts HBCUs lack engineering

programs, requiring students to take extra courses. There is a need for more bottom-up creation of materials, resources, guidance based on what is needed at HBCUs. Despite some challenges, like a racial incident during the SURF program, students reported positive experiences, particularly valuing mentorship. Project leadership is making adjustments, including developing a core curriculum with multiple tracks and enhancing support for new faculty and students.

The implementation of the HBCU Pilot has faced both opportunities and challenges, consistent with the literature on partnerships between HBCUs, MSIs, and PWIs. Research indicates that successful implementation often hinges on leadership commitment to STEM fields and the support of necessary infrastructure (Jaeger et al., 2021). At the same time, partnerships can encounter difficulties when they do not adequately account for existing institutional models and systems (Warren et al., 2021).

Based on the interviews conducted, some faculty have been active in recruiting students, tailoring efforts to students in computer science and math. However, the curriculum has been a challenge as it is often designed for engineering programs, which many liberal arts HBCUs lack. This misalignment requires students to take additional courses outside of their major, creating barriers to participation. There is a need for more bottom-up creation of materials, resources, guidance based on what is needed at HBCUs. Faculty shared that their recruitment has involved direct outreach via class visits, emails, and engagement through institutional supports like the Director of Student Services on campuses. However, there is a desire for greater faculty collaboration across cohorts to strengthen program implementation.

Students' experiences in the *SURF* program have been largely positive. Participants reported that mentorship was a key success factor, with mentors providing support and constant communication. One student described her relationship with her mentor:

- *Well, the biggest thing for me this summer was my, I would say, my lab placement, like my skill mentor, his research I was able to help with, since I'm a math major. But I don't know if I had been placed with any other research mentor if I would have been qualified enough, just because, like I said, I haven't done any engineering... I think I just got lucky this summer, and my SCALE mentors were also very helpful.*

However, some challenges were noted, such as students facing an incident involving a racial slur during the SURF program. Despite this, students emphasized the value of the research experience and mentorship.

Project leadership has acknowledged that adjustments to the program structure, such as creating a core curriculum with multiple tracks, have been promising. A leader in the pilot program explained:

- *Overall, the program has adapted to work well for the participating HBCUs. The adjustments to create a core curriculum with multiple tracks, leveraging a combination of local courses and online content seems very promising.*

Other leaders highlighted the need for more organized curriculum support, particularly for new faculty and students.

Effectiveness

❖ **Evaluation Question #3. Effectiveness:** *How effectively are the key components (curriculum, internships, clearances, outreach) of the project operating? What is working well and for whom? What are areas for improvement?*

Finding #3: The effectiveness of the HBCU Pilot varies across its key components: curriculum, internships, security clearances, and outreach. While students have gained confidence and professional skills through the program, the curriculum remains a challenge due to misalignment with the needs of liberal arts HBCUs, limiting student accessibility and recruitment. Positive feedback from Summer 2024 participants indicates strong impact, with some expressing interest in returning. Additionally, the program is addressing the lengthy security clearance process, which is crucial for careers in this field, by exploring ways to expedite it and providing guidance to students.

The program's key components—curriculum, internships, security clearances, and outreach—have shown varying levels of effectiveness. Faculty noted that while some students performed well during their SURF experience and were highly regarded by Purdue, the curriculum remains a challenge. The SCALE courses are not yet fully integrated with the existing curricula at some HBCUs, which limits accessibility for students. One faculty explained the impact the misaligned curriculum has on student recruitment:

- *Well, with Tougaloo College, there are some issues because a lot of the curriculum that has been designed up to this point is geared toward engineering schools. And so, one of the issues that I've been discussing with [omitted], [omitted], and people who are involved with this partnership is that most HBCUs, in particular, liberal arts schools like Tougaloo College, don't have an extra semester or whole year to take these new classes. The other issue is we don't have those courses available on our campuses. And so again, that's an issue with how these students are going to take these classes since we can't offer them on campus. So those are the main issues with the current curriculum. It's really hard to match up that curriculum they have designed at this point with what we have and also what students are looking for. So, we have some issues there. We have had a difficult time recruiting students because, again, the number of courses they would have to take is in a totally different area from their current major. So even with computer science—and I'm a computer scientist—I know there are connections with computer science, but when you look at the curriculum, it doesn't match up or it's not as closely related as we would like to have it in terms of computer science, because students don't want to spend an extra semester or whole year taking these new classes.*

In contrast, students reported that the program helped them develop professionally and academically, citing increased confidence in writing scientific papers and networking. The SCALE program was also praised for making opportunities accessible to students from non-engineering backgrounds, which broadened their career prospects.

Project leadership has reported that the students who participated in Summer 2024 had overwhelmingly positive experiences. Some expressed interest in returning for a second summer, indicating the program's strong impact. Leadership also emphasized the interconnectedness of recruiting, curriculum-based certificates, and summer research activities, acknowledging that initial recruitment efforts were challenging but that momentum has since grown with more schools on board.

A unique aspect of this program involves preparing students for careers that may require security clearance. Literature on security clearance processes for students in semiconductor programs is sparse, but what is available highlights the need for efficiency and support in navigating the clearance process (McDaniel, 1989; Hughes et al., 2013). Security clearances, particularly for careers in radiation-hardened microelectronics, are essential but can take anywhere from 6 to 18 months to obtain, creating a potential bottleneck for students entering the workforce. The project team is exploring ways to expedite the clearance process and ensure that students are adequately prepared. They are reviewing best practices from other programs and providing guidance to students on how to navigate the clearance process, such as reviewing credit reports and ensuring accuracy in background checks.

Outcomes

❖ **Evaluation Question #4. Outcomes:** *What have been the direct results of the project's activities in terms of the numbers of project participants and events, and participants' immediate outcomes related to the key components: curriculum, internships, clearances, outreach? To what extent are participants diverse (gender, ability status, ethnicity/race, geographic region, socio-economic status, etc.)?*

Finding #4: The HBCU Pilot has positively impacted students by enhancing their interest in research, graduate school, and technical careers. Participants reported gaining valuable research experience, developing professional skills, and building confidence, with one student noting how the program provided insight into real lab work and its applications. The program has effectively attracted a diverse group of participants, including those from non-engineering majors and underrepresented backgrounds in STEM. However, improvements are still needed to better align the curriculum with the needs of liberal arts HBCUs, ensuring students can participate without requiring additional courses outside their majors.

The HBCU Pilot has had a positive impact on participating students, particularly in increasing their interest in research, graduate school, and technical careers. Students reported that the program helped them gain valuable research experience, develop professional skills, and build confidence in their academic and career pursuits. A student shared how SCALE fulfilled her expectations for what she hoped to achieve:

- *I wanted to see what it was like actually working in a research lab because the research that I had done during the school year was more like after my classes and stuff; it wasn't really like at an actual lab. And I also wanted to see how engineering would be. Like I said, I had most of my work at Tougaloo, more theoretical, like math and computer science. So I wanted to see where the application could come in. And I think SCALE was pretty good in showing me that.*

In terms of diversity, the program has succeeded in attracting students from a range of backgrounds, including those with non-engineering majors and those from underrepresented groups in STEM fields. However, there is still room for improvement in terms of aligning the curriculum with the needs of liberal arts HBCUs and ensuring that students can fully participate without having to take additional courses outside their major.

Communication

❖ **Evaluation Question #5. Communication:** *To what extent is effective communication and management taking place within the HBCU Pilot program (across key participants)? How and in what ways can communication and management be improved? How is anti-deficit thinking currently communicated and integrated within the HBCU Pilot program?*

Finding #5: Communication within the HBCU Pilot program varies among participants, revealing both strengths and challenges. Some faculty report that meetings primarily focus on curriculum adaptation, but frustrations with certain program administrators and reliance on email hinder real-time collaboration. Conversely, other faculty find the communication effective, citing responsive leadership that provides clear guidance and useful recruitment resources, facilitating smoother implementation. To improve overall communication, enhancing real-time engagement methods and addressing administrative concerns would be beneficial. The program currently integrates anti-deficit thinking by fostering supportive communication and emphasizing the potential of students from diverse backgrounds.

Effective communication within the HBCU Pilot program is occurring to varying degrees across the key participants, but there are areas for improvement. First, leadership should spend some time clarifying their roles and activities and review if there are any duplication of efforts. Activities like the logic model focus group initiated necessary discussion about the various roles. In addition, the faculty at different institutions have noted both strengths and challenges in the current communication and management structures. Faculty reported, at some institutions, that communication primarily revolves around meetings focused on the curriculum, specifically discussions about how to adapt and integrate the program into their institutional framework. These meetings typically involve faculty from institutions, representatives from other institutions such as Purdue, and key interest holders from TCRDF. While there are regular meetings to address various program components, faculty have expressed frustration with issues related to certain program administrators. In addition, there have been a few virtual onboarding meetings designed to assist faculty in their roles as mentors and ambassadors for the program. Despite these meetings, much of the ongoing communication happens via email, which faculty feel limits real-time collaboration and engagement.

In contrast, faculty at other institutions have found the communication and management of the program to be largely successful. They reported that the leadership has been responsive and explained processes well, offering clear guidance and resources, especially in the area of student recruitment. They explained:

- *It's been pretty successful. They've been very responsive. They've explained things well to me and gave me an idea of what I will be responsible for starting off. So, it has been pretty smooth, and they've even just recently provided me with some resources to help with my recruiting. So that was good as well.*

This institution has benefited from access to recruitment tools and strategies, which has facilitated a smoother implementation process. The ongoing communication has helped to ensure that faculty feel well-supported and equipped to engage students effectively.

Diversity, Equity, and Inclusion (DEI)

❖ **Evaluation Question #6. DEI:** *How and in what ways is the HBCU Pilot program leadership attending to diversity, equity, inclusion, and cultural issues across components (TCRDF, Purdue, Parallax)? What strategies does the project use to implement an anti-deficit framework, focusing on the strengths and potential of underrepresented groups rather than their perceived deficiencies?*

Finding #6: The HBCU Pilot project leadership prioritizes diversity, equity, and inclusion by implementing an anti-deficit framework that highlights the strengths of underrepresented groups in STEM. While the program aims to increase representation, faculty have raised concerns about the curriculum's focus on engineering, which may limit accessibility for non-engineering majors. Project leadership acknowledges the need for ongoing improvements to ensure inclusivity, emphasizing the importance of understanding diverse student needs and encouraging feedback through surveys. This approach aims to create a more supportive environment that effectively meets the varied backgrounds and requirements of all participants.

The HBCU Pilot project leadership has emphasized diversity, equity, and inclusion (DEI) throughout its activities. The project's anti-deficit framework focuses on leveraging the strengths of underrepresented groups rather than highlighting their deficiencies. This is particularly important given the program's focus on increasing representation in STEM fields.

Faculty have expressed concerns about the inclusion of non-engineering majors in the program, noting that the curriculum is primarily designed for engineering students. This raises important questions about how the program can better serve students from diverse academic backgrounds.

Overall, project leadership has acknowledged that while progress has been made in creating a more inclusive environment, there is still work to be done to ensure that the program is accessible to all students. One faculty member stated:

- *Sometimes we address it as a group setting, but it's a person-to-person thing. I understand there's gonna be different scenarios and a lot of cases, and so understanding how to maneuver around those situations and still create a successful opportunity for somebody is necessary. So, I would say, be as inclusive as possible to understanding what the students need. While you're providing the education to them, sometimes it's just as good to have a survey, understanding whether or not how things are disseminated or expressed to them...are they effective enough to allow the students to absorb the information accurately? Are there other ways?*

❖ **Evaluation Question #7. Sustainability:** *How and to what extent can elements of the project be institutionalized and sustained at the university or partner schools? What aspects of this project can be useful to other SCALE institution partners?*

Finding #7: Sustainability poses a significant challenge for partnerships between Predominantly White Institutions and Minority-Serving Institutions like HBCUs, as many collaborations rely heavily on grant funding, which often fails to establish lasting infrastructure. For the HBCU Pilot for Radiation-Hardened Microelectronics, institutionalizing elements such as a more inclusive curriculum is essential for long-term success, allowing the program to persist beyond grant funding and reach a broader student base. Project leaders believe that some student support services, like mentoring and

professional development, may continue through existing university resources, but the overall impact will depend on securing ongoing funding. If funding expires in August 2025, the program's ability to support a larger group of students will be significantly constrained.

Sustainability is a key challenge in partnerships between Predominantly White Institutions and Minority-Serving Institutions/Historically Black Colleges and Universities. Research highlights that many such collaborations are primarily grant-funded, and while they often lead to the introduction of new programming, the funding alone is insufficient to establish the necessary infrastructure for long-term sustainability (Smith et al., 2021; Warren et al., 2019). Variability in institutional capacity across universities can also lead to inconsistent implementation of programs, ultimately resulting in their early termination (Warren et al., 2019).

In the context of the HBCU Pilot program, institutionalizing certain elements of the project at the participating universities is critical for long-term success. According to a faculty member, a more inclusive and diverse curriculum would be necessary to scale the program effectively across campuses. Embedding this curriculum into the standard offerings at both partner HBCUs and collaborating PWIs would allow the program to persist beyond the grant period and serve a wider range of students. One program leader emphasized the need to refine the radiation-hardened microelectronics curriculum to benefit both students and faculty in order to promote sustainability. The leader explained:

- *Many of the SCALE student support services are being leveraged to benefit students in this program. One of the SCALE-wide needs that may particularly help this effort is increased organization of the RH curriculum to benefit new faculty and students.*

The project leaders acknowledge that since this pilot is part of the larger SCALE initiative, certain student support services are likely to continue even if additional funding is not secured. Services such as mentoring, professional development, and student networking might be sustained through existing university resources or other ongoing initiatives. However, the ability to extend these benefits to a larger group of students remains contingent on continued funding. If the grant expires in August 2025, as projected, the program will only be able to support the current cohort of students, limiting its potential impact.

RECOMMENDATIONS

To ensure the success and sustainability of the HBCU Pilot program, and to strengthen its impact across the SCALE network, several key recommendations have been identified.

1. **Address barriers to curricular integration at HBCU partner institutions.** First, it is essential to consider the unique contexts and academic structures of HBCUs in the development of the SCALE curriculum. Many HBCUs lack dedicated engineering programs, which presents a challenge in aligning their academic offerings with the specialized focus of the SCALE initiative. To address this issue, the curriculum should be designed to be both flexible and accessible to students from diverse academic backgrounds, including those from non-engineering disciplines. Incorporating interdisciplinary approaches that allow students who attend schools with engineering adjacent programs to meaningfully participate would expand the program's reach and relevance.

2. **Work collaboratively with HBCU faculty to co-develop course content.** In addition to adapting the existing curriculum, SCALE leadership could work collaboratively with HBCU faculty and administrators to co-develop course content that meets both the program's needs and the available resources at HBCUs. There is a need for more bottom-up creation of materials, resources, and guidance based on what is needed at HBCUs. This approach ensures that the curriculum remains relevant and implementable across a range of institutions, thereby increasing the likelihood of long-term adoption and sustainability. Collaboration could also involve creating supplementary modules or courses that introduce basic engineering concepts to non-engineering students, preparing them to engage fully with the SCALE program.
3. **Expand interdisciplinary opportunities to increase student engagement.** Expanding interdisciplinary opportunities is another component for ensuring broader student engagement with the SCALE program. Many students at HBCUs are studying disciplines such as biology, chemistry, and mathematics, which have potential intersections with microelectronics. Creating pathways for students in these disciplines to participate in SCALE initiatives would attract a larger student base and promote the integration of engineering principles across various academic fields.
4. **Strengthen recruitment and outreach efforts.** To maintain momentum and increase participation, it is important to strengthen recruitment and outreach efforts. Partnerships with HBCU student organizations, particularly those focused on STEM, could raise awareness and promote participation in the program. Establishing ways to connect current SCALE students with potential recruits could further foster peer engagement and encourage interest in the field. One faculty member stated "*Exposure and presence, keep students in front. After students go through [the program], have them come back and bring in the new students.*"
5. **Adopt a more intentional approach to the recruitment of students for the RH-pipeline program.** By actively seeking out individuals who demonstrate a genuine interest in the program, we can ensure that our efforts are focused on candidates who are truly invested in their development within the field. This strategic alignment will not only enhance the overall quality of the students but also optimize the use of time and resources, ultimately leading to more successful outcomes for both the students and the program.
6. **Collaborate to provide more structured opportunities for partnership and SCALE capacity building among leadership.** Collaborating to provide more structured opportunities for partnership and SCALE capacity building among leadership is crucial for enhancing the effectiveness of the HBCU Pilot program. By fostering stronger connections between institutions, leaders can share best practices, resources, and strategies that promote mutual growth and sustainability. This collaborative approach not only strengthens the network but also empowers leadership to implement innovative solutions that address shared challenges. Ultimately, such partnerships can create a more cohesive framework for advancing diversity and inclusion in STEM education across all participating institutions.
7. **Continue evaluation of this project.** Finally, continuing the evaluation of the HBCU Pilot project is vital for understanding its long-term effectiveness and impact. Ongoing assessments can identify successful strategies and highlight areas for improvement, ensuring that the program adapts to the evolving needs of students and institutions. By

gathering data and feedback, interest holders can make informed decisions that enhance the program's sustainability and alignment with its goals.

CONCLUSION

The HBCU Pilot program, as part of the larger SCALE initiative, has made significant strides in advancing educational opportunities and access to specialized fields of microelectronics for students at Historically Black Colleges and Universities. The program has facilitated the development of new academic and mentorship pathways, helping to bridge the gap between underrepresented students and cutting-edge fields like radiation-hardened systems. However, several challenges remain, particularly around the sustainability of these efforts, the alignment of curriculum with the unique academic structures of HBCUs, and concerns with recruitment and outreach.

The partnerships between SCALE institutions and HBCUs have shown the potential for positive impact, but they also highlight the need for greater flexibility and adaptation of the curriculum to account for institutions that lack engineering programs. Building the necessary infrastructure at HBCUs, investing in faculty development, and providing students from diverse academic backgrounds with accessible entry points into the field are essential to sustaining the program's future success.

To fully realize the potential of the HBCU Pilot, a concerted effort must be made to institutionalize key elements of the program at participating schools, engage a wider range of students, and ensure that recruitment and support systems are in place. Overall, this project has laid a solid foundation for the integration of minority-serving institutions into high-tech fields, and with ongoing commitment from interest holders, adaptive strategies, and long-term funding, the program will continue to grow and impact future generations of students.

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APPENDIX A

HBCU PILOT FOR RADIATION-HARDENED MICROELECTRONICS LOGIC MODEL

Inputs	Activities	Outputs	Outcomes	Impact
<p>Financial Resources:</p> <ul style="list-style-type: none"> Total funding of \$4,219,880 over two years. Cost share from industry and Purdue University. <p>Human Resources:</p> <ul style="list-style-type: none"> Expertise and faculty from Purdue University and partner institutions. Ambassadors and mentors from Tougaloo College Research and Development Foundation (TCRDF). Program management and SMEs from Parallax Advanced Research. <p>Physical Resources:</p> <ul style="list-style-type: none"> Laboratory equipment including radiation detection stations, neutron detectors, HPGe detectors, and alpha spectrometers. <p>Partnerships:</p> <ul style="list-style-type: none"> Collaboration with 5 HBCUs under TCRDF. Industry partnerships for internships and job placements. Government agency partnerships for security clearances and research opportunities. 	<p>Curriculum Development and Deployment:</p> <ul style="list-style-type: none"> Design and implement coursework in Radiation-Hardened Modeling & Simulation, Radiation-Hardening by Design, and Test and Analysis. Incorporate new modules into existing university curricula. Deploy new courses via Purdue Online and at participating HBCUs. <p>Laboratory Equipment Setup:</p> <ul style="list-style-type: none"> Purchase and install radiation effects laboratory equipment at participating HBCUs. Train faculty and students in equipment use and safety protocols. <p>Summer Research Experiences:</p> <ul style="list-style-type: none"> Conduct 10-week immersive research experiences at Purdue and participating universities. Mentor students in research methodologies and presentation skills. Facilitate student participation in research symposiums. <p>Internship Placement:</p> <ul style="list-style-type: none"> Facilitate student placements in internships with government and industry partners. Match students with relevant internship opportunities through the Connect ME portal. <p>Clearance Processing:</p> <ul style="list-style-type: none"> Assist students in obtaining necessary security clearances for employment. Expedite clearance processing through the C2LC pilot program. <p>Outreach and Engagement:</p> <ul style="list-style-type: none"> Recruit students through On-Campus Ambassadors and visiting technologists/executives programs. Organize student conferences and outreach events. Expand the Connect ME portal to include relevant opportunities and partnerships. 	<p>Educational Outputs:</p> <ul style="list-style-type: none"> Trained students with credentials in Radiation-Hardened Microelectronics. Enhanced curriculum at participating HBCUs. <p>Research Outputs:</p> <ul style="list-style-type: none"> Research projects and findings presented at symposiums. Publication of research results and presentations. <p>Placement Outputs:</p> <ul style="list-style-type: none"> Number of students placed in internships and post-graduation jobs. Students obtaining security clearances for defense-related careers. 	<p>Short-Term Outcomes:</p> <ul style="list-style-type: none"> Increased student enrollment and engagement in RH microelectronics. Enhanced faculty expertise and curriculum at participating HBCUs. <p>Medium-Term Outcomes:</p> <ul style="list-style-type: none"> Improved job placement rates for program graduates. Strengthened partnerships between HBCUs, Purdue, and industry/government. <p>Long-Term Outcomes:</p> <ul style="list-style-type: none"> Sustainable pipeline of diverse talent in Radiation-Hardened Microelectronics. Advancement of national security through skilled workforce development. 	<p>Institutional Impact:</p> <ul style="list-style-type: none"> Strengthened academic programs and infrastructure at participating HBCUs. Enhanced reputation and capacity for Purdue in microelectronics education. <p>Community Impact:</p> <ul style="list-style-type: none"> Increased diversity and representation in high-tech fields. Economic growth through skilled workforce development.

APPENDIX B

HBCU PILOT FOR RADIATION-HARDENED MICROELECTRONICS
EVALUATION FRAMEWORK

Evaluation Questions	Indicators	Data Sources	Data Collection Methods
<p>EQ1: What is the shared vision of the HBCU Pilot for the Radiation-Hardened Microelectronics program? How and in what ways does it vary across interest holders (TCRDF, Purdue, Parallax)?</p>	<ul style="list-style-type: none"> - Clear articulation of the program's vision - Alignment of vision among interest holders - Variations in interpretation and focus 	<ul style="list-style-type: none"> - Grant proposal - Project team members 	<ul style="list-style-type: none"> - Document reviews - Interviews - Focus groups
<p>EQ2: What aspects of the project's activities have been implemented as planned; what opportunities, challenges, and difficulties have been encountered; and how have the project's activities been modified as a result?</p>	<ul style="list-style-type: none"> - Number/types of activities implemented - Opportunities, challenges, and difficulties identified - Modifications to activities made (or planned for future years) - Degree of adherence to project plan - Identification of challenges and opportunities - Adaptations and modifications made 	<ul style="list-style-type: none"> - Project team members - HBCU Faculty (Collaborators) - Students - SCALE Faculty - TCDRF SCALE Curriculum - Project meetings - Project documentation 	<ul style="list-style-type: none"> - Interviews - Surveys - Focus groups - Meeting observations
<p>EQ3: How effectively are the key components (curriculum, internships, clearances, outreach) of the project operating? What is working well and for whom? What are areas for improvement?</p>	<ul style="list-style-type: none"> - Satisfaction of participants, teachers, project team members, and any other interest holders - Program successes identified - Areas for improvement identified 	<ul style="list-style-type: none"> - Students - SCALE Faculty - TCDRF SCALE Curriculum - Project team members - HBCU Faculty (Collaborators) - Project meetings - Project documentation 	<ul style="list-style-type: none"> - Interviews - Surveys - Focus groups - Meeting observations

Evaluation Questions	Indicators	Data Sources	Data Collection Methods
<p>EQ4: What have been the direct results of the project’s activities in terms of the number of project participants and events, and participants’ immediate outcomes related to the key components: curriculum, internships, clearances, outreach?</p>	<ul style="list-style-type: none"> - Number/types of participants & nature of participation/progress - Participant outcomes/ impacts identified (e.g., skills gained, job placements) - Diversity metrics 	<ul style="list-style-type: none"> - Students - SCALE Faculty - TCDRF SCALE Curriculum - Project team members - HBCU Faculty (Collaborators) - Project meetings - Project documentation 	<ul style="list-style-type: none"> - Interviews - Document Review - Surveys
<p>EQ5: To what extent is effective communication and management taking place within the HBCU Pilot for Radiation-Hardened Microelectronics program (across key participants)? How and in what ways can communication and management be improved? How is anti-deficit thinking currently communicated and integrated within the HBCU Pilot for Radiation-Hardened Microelectronics program?</p>	<ul style="list-style-type: none"> - Communication frequency and clarity - Management effectiveness - Integration of anti-deficit thinking 	<ul style="list-style-type: none"> - Project team members - SCALE Faculty - Students - Project meetings - Project documents 	<ul style="list-style-type: none"> - Interviews - Document Review - Surveys
<p>EQ6: How and in what ways is the HBCU Pilot for Radiation-Hardened Microelectronics project leadership attending to diversity, equity, inclusion, and cultural issues across components (TCRDF, Purdue, Parallax)? What strategies does the project use to implement an anti-deficit framework, focusing on the strengths and potential of under-represented groups rather than their perceived deficiencies?</p>	<ul style="list-style-type: none"> - DEI initiatives - Implementation of anti-deficit strategies - Interest holder perception of DEI efforts 	<ul style="list-style-type: none"> - Students - SCALE Faculty - TCDRF SCALE Curriculum - Project team members - HBCU Faculty (Collaborators) - Project meetings - Project documentation 	<ul style="list-style-type: none"> - Interviews - Document Review - Surveys - Focus Groups

Evaluation Questions	Indicators	Data Sources	Data Collection Methods
<p>EQ7: How and to what extent can elements of the project be institutionalized and sustained at the university or partner schools? What aspects of this project can be useful to other SCALE institution partners?</p>	<ul style="list-style-type: none"> - Aspects of the program being institutionalized and/or sustained - Aspects of the program being institutionalized and/or sustained at the partner schools - Institutionalization plans - Sustainability measures 	<ul style="list-style-type: none"> - Project team members - Teachers - HBCU Faculty (Collaborators) - Project meetings - Project documentation 	<ul style="list-style-type: none"> - Interviews - Document Review - Survey

APPENDIX C

HBCU PILOT STUDENT INTERVIEW

Thank you for joining us today. Our names are _____, and this is _____. We are part of the external evaluation team for the SCALE HBCU Pilot program. The purpose of our evaluation work is to really reflect on the purpose of SCALE, its strengths and areas for improvement, as well as further refinement of SCALE as we move into the coming years of the program.

In particular, the purpose of today's meeting is for us to learn about your experiences with the SCALE HBCU Pilot program as students of the program. We are interested in getting authentic reflections and perspectives from you that we can share with SCALE program leadership so that they can make changes to the program accordingly.

This activity should last approximately 60 minutes. To facilitate this conversation, we will ask you questions related to your experiences with the SCALE HBCU Pilot program. When you share, be sure to speak up to ensure that the recording captures your complete response. It is important to remember that the role of the evaluation team is to capture your experiences and provide the most helpful information possible to program leadership so that they can make informed decisions regarding how to make the program the best it can be moving forward.

Introduction and Background (10 minutes)

1. Tell me a little bit about your background:
 - a. University attended
 - b. Classification (e.g., freshman, sophomore, junior, senior, graduate student)
 - c. Major
 - d. Do you have a mentor?
 - e. When did you join SCALE HBCU Pilot program?
2. How did you get involved in the SCALE HBCU Pilot program?

Application and Purpose (10 minutes)

3. In your own words, what is the purpose of SCALE HBCU Pilot program?
 - a. Why did you decide to apply to the SCALE HBCU Pilot program (how did you hear about it)?
 - b. What do you hope to gain from your experience in SCALE HBCU Pilot program?
4. What did the SCALE HBCU Pilot program application process look like?
 - a. Tell us a little bit about the application process.
 - b. Why did you decide to apply to the SCALE HBCU Pilot program (how did you hear about it)?
 - c. What challenges did you face when applying to SCALE HBCU Pilot program?
 - i. What was easy about the application process?

Experience and Feedback (10 minutes)

5. Can you tell me about your overall experience in SCALE HBCU Pilot program?
 - a. What did you do within the SCALE HBCU Pilot program?
 - b. What does your day look like?
 - c. What aspects are working really well?
 - d. What aspects could be improved moving forward?

6. How has your coursework prepared you to engage in microelectronics?

Internship and Research Experience (5 minutes)

7. How do students find out about internships in SCALE?
 - a. How could internship opportunities be made more accessible to students?

Diversity, Equity, and Justice (10 minutes)

8. How does SCALE HBCU Pilot program at your university attend to diversity, equity, and justice in the following areas?
 - a. Coursework
 - b. Recruitment
 - c. Mentoring
 - d. Program Planning & Activities
 - e. Overall Student Cohort Composition (including gender, ability status, ethnicity/race, geographic region, socio-economic status)

Impact and Future Considerations (5 minutes)

9. How has your participation in SCALE HBCU Pilot program impacted you academically and professionally? (please provide 1-2 examples)

10. If this program were to be replicated or implemented elsewhere, what would be the most important thing for those running the program to consider?
 - a. What types of things would need to be in place or studied to make this program work somewhere else?

APPENDIX D

HBCU PILOT FOR RADIATION-HARDENED FACULTY INTERVIEW PROTOCOL

Thank you for joining us today. Our names are _____, and this is _____. We are part of the external evaluation team for the HBCU Pilot for Radiation-Hardened Microelectronics program. The purpose of our evaluation work is to really reflect on the purpose of SCALE, its strengths and areas for improvement, as well as further refinement of SCALE as we move into the coming years of the program.

This interview should last approximately 60 minutes. We will ask you questions related to your experiences with the HBCU Pilot for Radiation-Hardened Microelectronics as a faculty PI in the consortium. In particular, the purpose is for us to learn about your experiences with HBCU Pilot for Radiation-Hardened Microelectronics program as a faculty member in the consortium and how it is operating within the HBCU Pilot for Radiation-Hardened Microelectronics program. In addition, we want to know how does the consortium meet the needs of both faculty members and students? We are interested in getting authentic reflections and perspectives from you that we can share with SCALE program leadership so that they can make changes to the program accordingly.

The conversation today will be audio recorded and transcribed. These recordings will be permanently deleted once the transcriptions are complete and will only be available to the research team. Your name will not be associated with any of your responses in any of the transcriptions, and we will make every attempt to keep your identity confidential, as outlined in the informed consent. It is important to remember that the role of the evaluation team is to capture your experiences and provide the most helpful information possible to program leadership so that they can make informed decisions regarding how to make the program the best it can be moving forward.

1. Can you tell me a little bit about your background and position?
2. What motivated your involvement in the HBCU Pilot for Radiation-Hardened Microelectronics program?
3. What do you see as the purpose of the HBCU Pilot for Radiation-Hardened Microelectronics program?
4. How does the SCALE program fit into your university?
 - a. Can you share how the HBCU Pilot for Radiation-Hardened Microelectronics program operates in your local unit (e.g., department, school, college, centers)?
5. What value does SCALE bring to your university and its students?
6. What does it look like to be a HBCU Pilot for Radiation-Hardened Microelectronics program student at your university?
 - a. How many SCALE students do you have at your university?
7. What does the recruitment process look like, and how do students find out about the HBCU Pilot for Radiation-Hardened program ?

8. How does communication and collaboration with Purdue and the HBCU Pilot for Radiation-Hardened program consortium work?
9. How does the HBCU Pilot for Radiation-Hardened Microelectronics program facilitate a community of practice among its members and students?
10. What do you see as the role of diversity, equity, and inclusion in HBCU Pilot for Radiation-Hardened Microelectronics program?
 - a. What opportunities and barriers to increasing participant diversity exist in the HBCU Pilot for Radiation-Hardened Microelectronics program?
11. From your perspective, how can the HBCU Pilot for Radiation-Hardened Microelectronics program better attend to diversity, equity, inclusion, and culture in its operations?
12. What's working well with the HBCU Pilot for Radiation-Hardened Microelectronics program so far?
13. What aspects of the HBCU Pilot for Radiation-Hardened Microelectronics program could be improved moving forward?
14. How can the HBCU Pilot for Radiation-Hardened Microelectronics program further meet the needs of your university and its students as we think about sustainability?
15. What would successful scaling of the HBCU Pilot for Radiation-Hardened Microelectronics program look like?
16. What is the best way to get in contact with your students?

APPENDIX E

SCALE HBCU PILOT PROGRAM LEADERS INTERVIEW PROTOCOL

Thank you for joining us today. Our names are _____, and this is _____. We are part of the external evaluation team for the SCALE HBCU Pilot program. The purpose of our evaluation work is to really reflect on the purpose of SCALE, its strengths and areas for improvement, as well as further refinement of SCALE as we move into the coming years of the program.

In particular, the purpose of today's meeting is for us to learn about your experiences with the SCALE HBCU Pilot as leaders of the program. We are interested in getting authentic reflections and perspectives from you that we can share with SCALE program leadership so that they can make changes to the program accordingly.

This activity should last approximately 60 minutes. To facilitate this conversation, we will ask you questions related to your experiences with SCALE HBCU Pilot.

The conversations today will be audio recorded and transcribed. These recordings will be permanently deleted once the transcriptions are complete and will only be available to the research team. Your name will not be associated with any of your responses in any of the transcriptions, and we will make every attempt to keep your identity confidential, as outlined in the informed consent. It is important to remember that the role of the evaluation team is to capture your experiences and provide the most helpful information possible to program leadership so that they can make informed decisions regarding how to make the program the best it can be moving forward.

1. Tell me a little bit about your background:
 - a. Academic Background
 - b. Professional Background
 - c. Role in SCALE HBCU Pilot program?
2. What is the SCALE HBCU Pilot program?
 - a. What do you see as the goals of the project?
 - b. What is the project timeline?
3. How are things going thus far for the SCALE HBCU Pilot program?
 - a. What successes and challenges have you encountered so far?
4. What are the key activities supported by the program?
 - a. Are there any activities that jump out at you as particularly impactful or any that were more challenging or maybe less useful?
 - b. What is the timeline for these activities?
5. How frequently do the participants meet? What are the meetings like?
6. What do you see as the overall impact of the SCALE HBCU Pilot program?
7. Considering the sustainability of these programs, what measures have been taken to maintain their impacts beyond the initial funding period?
 - a. What initiatives or strategies are in place to ensure the programs' longevity?

8. During the current cycle, what additional support is needed to sustain the impacts of these programs in the future?
 - a. Are there specific resources or assistance required to continue the programs' success?

9. At this point, where and how can the external evaluation team be most useful to the SCALE HBCU Pilot program leadership?
 - a. What can the external evaluation bring, in addition to what you all have done internally?

APPENDIX F

SCALE HBCU PILOT PROGRAM: KEY TAKEAWAYS



Key Takeaways

External Evaluation

Initial Phase of the SCALE HBCU Pilot for Radiation-Hardened Microelectronics

Program Overview and Purpose

The HBCU Pilot, part of the SCALE initiative, collaborates with key partners (Purdue University for curriculum development, the Tougaloo College R&D Foundation for recruitment and outreach, and Parallax Advanced Research for program management and internships) to enhance the representation of people of color in the STEM fields, specifically in Radiation-Hardened (RH) microelectronics critical for military, civil, and commercial systems.

External Evaluation

The external evaluation, led by the STEM Program Evaluation Lab, employs a robust and values-engaged approach, utilizing interviews, focus groups, and continuous feedback mechanisms to gather comprehensive data from students, faculty, and project leaders. This methodology ensures a deep understanding of the program's nuances and participant experiences. The findings, while preliminary, are based on data from a variety of stakeholders. They offer a meaningful snapshot of early program implementation and initial impacts, providing a solid basis for ongoing and future evaluations.

Current Insights into the HBCU Pilot Initiative

- **Alignment and Integration:** The program aims to integrate with the broader SCALE initiative, but there are evident challenges in aligning the specialized curriculum with HBCU academic structures, particularly at liberal arts institutions without existing engineering programs.
- **Stakeholder Perspectives:** Diverse objectives among key collaborators (TCRDF, Purdue, and Parallax) indicate both a rich opportunity for cross-pollination and a potential for misalignment. Understanding and reconciling these differing perspectives will be important for cohesive program execution.
- **Communication Gaps:** While there are strong elements of collaboration, communication inconsistencies could hinder the program's efficiency and effectiveness. Streamlining communication and ensuring all partners have a common understanding of goals and methods is important as the pilot continues to develop.

Recommendations for Future Focus

Recommendations and potential action steps for the SCALE HBCU Pilot Initiative are outlined below.

1. **Address Barriers to Curricular Integration at HBCU Partner Institutions:**
 - **Audit Current Curriculum:** Conduct a comprehensive review of existing curricula at HBCU partner institutions to identify gaps and misalignments with the SCALE initiative's requirements.
 - **Develop Flexible Curriculum Options:** Create modular curriculum components that can be integrated into existing courses or offered as standalone options to accommodate the varied academic structures of HBCUs.



- **Establish Joint Curriculum Development Teams:** Form collaborative teams comprising faculty from both SCALE and HBCU institutions to co-develop curriculum that meets the needs of diverse student bodies.
2. **Work Collaboratively with HBCU Faculty to Co-develop Course Content**
 - **Regular Collaboration Meetings:** Set up regular meetings between SCALE leadership and HBCU faculty to discuss and review curriculum development and implementation.
 - **Mutualistic Partnership and Bottom-Up Curriculum Development:** Facilitate collaborative workshops that bring together SCALE leaders and HBCU faculty to mutually identify curriculum needs and co-develop materials, ensuring that the curriculum development process is directly informed by the on-the-ground educational realities at HBCUs.
 - **Resource Sharing:** Establish a system for sharing educational resources, such as guest lectures, virtual labs, and collaborative research projects, between SCALE and HBCU partners.
 3. **Expand Interdisciplinary Opportunities to Increase Student Engagement**
 - **Identify Interdisciplinary Linkages:** Map potential intersections between RH microelectronics and other disciplines such as computer science, biology, and chemistry to identify opportunities for interdisciplinary courses.
 - **Develop Interdisciplinary Projects:** Create project-based learning opportunities that allow students from various disciplines to work on real-world problems related to RH microelectronics.
 - **Promote Interdisciplinary Research Initiatives:** Encourage and support interdisciplinary research projects among students and faculty across SCALE and HBCU institutions.
 4. **Strengthen Recruitment and Outreach Efforts**
 - **Enhance Visibility on HBCU Campuses:** Increase program visibility through targeted marketing campaigns, information sessions, and participation in campus events.
 - **Develop Targeted Recruitment Strategies:** Design recruitment strategies that specifically target students demonstrating interest and aptitude for RH microelectronics to get them into the workforce pipeline.
 - **Personalized Engagement Plans:** Create personalized engagement plans for recruited students to guide them from admission through to program completion and career placement.
 - **Develop Strategic Partnerships:** Form partnerships with key organizations and high schools that feed into HBCUs to build awareness and interest in RH microelectronics careers.
 5. **Collaborate to Provide More Structured Opportunities for Partnership and SCALE Capacity Building Among Leadership**
 - **Create Intentional Spaces for Collaboration:** Implement strategies to bolster communication among the differing levels of leadership in the project. This could include beginning to develop a theory of change for the SCALE HBCU Pilot or developing a detailed and ongoing plan for sustainability.
 - **Establish Leadership Forums:** Organize regular forums or roundtables that bring together leaders from SCALE and HBCU institutions to share best practices and discuss strategic directions.
 - **Create a Leadership Development Program:** Develop a program aimed at fostering leadership skills among faculty and administrators involved in the SCALE initiative, focusing on project management, partnership building, and innovation in education.

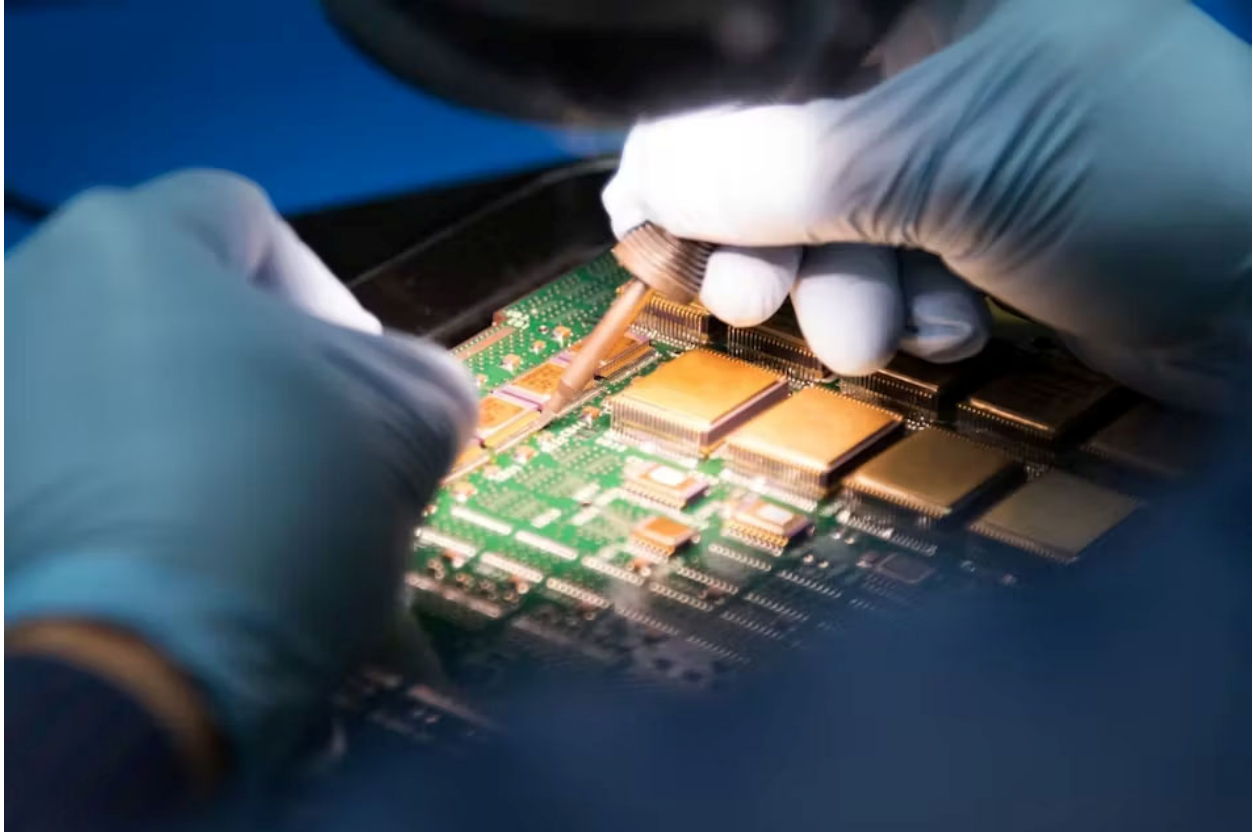


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