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Supplemental Instruction Leader Development and Student Learning in a Historically Black College Context: A Mixed-Methods Study of Virtual Peer-Led Learning

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ABSTRACT

This mixed-methods study examines Supplemental Instruction (SI) Leader experiences at a Historically Black College or University during the transition to virtual learning. Using a convergent design, data from undergraduate SI Leaders (N = 10) were collected via the SILVP Inventory. Quantitative results indicated strong perceived student learning, moderate leader development, and more variable program logistics. Qualitative findings highlighted interconnected themes of student engagement, leadership growth, and challenges in virtual delivery. Integrated results suggest that SI operates as a reciprocal system in which facilitating peer learning supports leader development. This study advances a conceptual double-impact model, positioning SI as a socially mediated learning environment that co-produces student outcomes and leadership development within culturally affirming institutional contexts.

Keywords: HBCU; peer leadership; mixed-methods; STEM identity; Supplemental Instruction; virtual learning

INTRODUCTION

Supplemental Instruction (SI) is a structured, peer-assisted learning model in which trained undergraduate leaders facilitate collaborative study sessions for historically challenging courses (Martin & Arendale, 1993; Arendale, 1997). SI is designed to enhance content mastery, knowledge retention, and course persistence by engaging students in active, peer-led problem solving rather than passive review.

A substantial body of research—including multi-institutional and longitudinal studies—has demonstrated that SI participation is associated with improved academic performance, course completion, and retention, particularly in STEM gateway courses (Achat-Mendes et al., 2022; Anfuso et al., 2022; Dawson et al., 2014). These outcomes are especially pronounced among historically underrepresented students in STEM, defined here as students from racial and ethnic groups underrepresented in the STEM workforce (e.g., Black/African American, Hispanic/Latinx, Native American), as well as first-generation college students and students from low-income backgrounds.

SI operates both as a programmatic intervention (structured sessions, trained leaders, coordinated implementation) and as a learning model grounded in collaborative and socially mediated learning processes. While the program structure provides consistency and scalability, the model itself emphasizes peer interaction, dialogue, and co-construction of knowledge as mechanisms for learning.

Within this structure, SI Leaders—undergraduate students who have successfully completed the target course—are responsible for facilitating sessions, guiding discussion, and supporting peer learning. SI Leaders typically undergo formal training in collaborative learning strategies, questioning techniques, and session planning, and they operate under the supervision of program coordinators and course faculty.

Serving as an SI Leader has been associated with the development of academic, interpersonal, and professional competencies, including communication skills, metacognitive awareness, and instructional confidence (Congos & Stout, 2003; Hoiland et al., 2021a, 2021b; Peterfreund et al., 2008). Research also suggests that SI leadership contributes to STEM identity development, conceptualized as a form of disciplinary and academic identity reflecting an individual's sense of belonging, competence, and recognition within a STEM field (Carlone & Johnson, 2007).

However, the majority of SI research has been conducted at Predominantly White Institutions (PWIs)—defined as institutions where White students constitute the majority of enrollment—and, to a lesser extent, other Minority-Serving Institutions (MSIs). In contrast, Historically Black Colleges and Universities (HBCUs) are institutions established prior to 1964 with the primary mission of educating Black students, and they are widely recognized for their supportive, culturally affirming learning environments and strong faculty–student mentorship structures (Gasman et al., 2017; Perna et al., 2009). These institutional differences are likely to influence both student learning and leadership development processes within SI programs.

Despite this, relatively little research has examined SI Leader experiences within HBCU contexts. This represents a meaningful gap, as the relational, community-oriented, and identity-affirming environments characteristic of HBCUs may shape SI leadership in ways not captured in prior studies.

Additionally, the COVID-19 pandemic introduced new instructional challenges, requiring SI Leaders to transition to virtual formats, adopt digital tools, and sustain peer engagement in online environments (Dawson et al., 2020; Hoiland et al., 2021b). These conditions provide a unique opportunity to examine how SI leadership operates under disrupted and technology-mediated learning conditions.

This study builds on prior work by Brown and Winborne (2025), which documented positive academic outcomes for SI participants at a mid-sized HBCU, particularly among first- and second-year STEM majors. These students are a primary target population for SI because they are disproportionately enrolled in gateway STEM courses that serve as critical transition points for persistence in STEM pathways.

Theoretical Framework

This study is grounded in social constructivist theory (Vygotsky, 1978; Bruner, 1996) and experiential learning theory (Kolb, 1984). Social constructivism posits that learning occurs through interaction, dialogue, and the co-construction of knowledge, which aligns with SI's emphasis on collaborative, peer-led problem solving. Experiential learning theory emphasizes learning through experience, reflection, and application, processes that are central to the SI Leader role as leaders facilitate sessions, reflect on their effectiveness, and refine their instructional practices.

Together, these frameworks support a reconceptualization of SI leadership as a socially mediated learning environment, in which SI Leaders simultaneously facilitate student learning and engage in their own developmental process. This

perspective provides a theoretical basis for examining the reciprocal relationship between student outcomes and leader development within SI programs.

Problem Statement

Although SI is widely recognized as an effective academic support model, less is known about how SI Leaders—particularly within HBCU contexts—perceive their roles, instructional impact, and professional development. Existing research has largely focused on SI participants and has been conducted primarily at PWIs, limiting understanding of how institutional context influences leadership experiences.

Furthermore, the transition to virtual instruction during the COVID-19 pandemic introduced additional complexities, including the need to adopt new technologies and maintain engagement in online environments (Dawson et al., 2020; Hoiland et al., 2021b).

To address these gaps, this study examines SI Leader perceptions of student learning, leadership development, and programmatic challenges within a virtual SI environment at an HBCU.

LITERATURE REVIEW

A growing and methodologically diverse body of research supports the effectiveness of Supplemental Instruction (SI) in improving student academic outcomes across STEM and other high-demand disciplines. This evidence base includes multi-institutional studies, quasi-experimental designs, and longitudinal analyses demonstrating improvements in course performance, persistence, and retention among SI participants (Achat-Mendes et al., 2022; Anfuso et al., 2022; Dawson et al., 2014). Foundational studies by Martin and Arendale (1993), Blanc and Martin (1994), and Arendale (1997) established SI as a scalable, peer-facilitated academic support model associated with increased course completion rates and reduced attrition.

Subsequent empirical research has further documented SI's positive impact on student learning, retention, and graduation outcomes, particularly among historically underrepresented students in STEM fields (Peterfreund et al., 2008; Dawson et al., 2014; Hoiland et al., 2021a). These findings suggest that SI may play a role not only in academic performance but also in supporting persistence pathways for students navigating structurally challenging gateway courses.

While the effectiveness of SI for participants is well established, research on SI Leaders remains comparatively limited. Existing studies indicate that serving as an

SI Leader is associated with gains in communication skills, metacognitive awareness, and disciplinary understanding (Congos & Stout, 2003; Lockie & Van Lanen, 2008). More recent work has also linked SI leadership to the development of STEM identity, defined here as a form of disciplinary and academic identity reflecting individuals' sense of belonging, competence, and recognition within a STEM field (Carlone & Johnson, 2007; Hoiland et al., 2021a, 2021b). Additionally, SI Leaders have been shown to develop mentoring skills, instructional confidence, and professional self-efficacy (Kochenour et al., 1997; Peterfreund et al., 2008).

However, this body of research has been conducted primarily at predominantly White institutions (PWIs), with limited attention to how institutional context influences SI Leader development. This represents an important limitation, as institutional environments shape not only academic experiences but also identity formation and leadership development processes. Historically Black Colleges and Universities (HBCUs), in particular, are recognized for their emphasis on culturally responsive pedagogy, strong faculty–student relationships, and supportive academic communities that contribute to student success in STEM (Gasman et al., 2017; Perna et al., 2009). Examining SI Leader experiences within HBCU contexts therefore offers an opportunity to extend existing research by considering how culturally affirming environments influence peer-led learning and leadership development.

In addition to institutional context, the shift to virtual learning during the COVID-19 pandemic introduced new dimensions to SI practice. Emerging studies on online and virtual SI have identified challenges related to student engagement, technological barriers, and adaptation of collaborative learning strategies to digital environments (Dawson et al., 2020; Hoiland et al., 2021b). However, little research has examined how these challenges are experienced specifically by SI Leaders, particularly within HBCU settings. Addressing this gap is critical for understanding how peer-led academic support functions under changing instructional conditions.

The present study addresses these gaps by examining SI Leader perceptions within an HBCU context during a period of virtual instruction, thereby extending prior research in three ways: (1) by centering SI Leaders as a population of interest, (2) by situating SI within a culturally specific institutional environment, and (3) by exploring leadership experiences under conditions of remote learning.

Theoretically, this study is grounded in social constructivist theory and experiential learning theory, which together provide a framework for understanding SI leadership as a socially mediated and reflective learning process.

Social constructivism posits that knowledge is co-constructed through interaction and dialogue (Vygotsky, 1978), a principle reflected in SI sessions where leaders facilitate collaborative problem-solving and peer engagement. Experiential learning theory (Kolb, 1984) emphasizes learning through experience, reflection, and application, which aligns with the iterative process through which SI Leaders develop instructional strategies, reflect on session effectiveness, and refine their approaches.

Together, these frameworks support a reconceptualization of SI leadership as both a learning environment and a developmental process, in which SI Leaders simultaneously facilitate student learning and engage in their own identity and skill development. This theoretical integration provides a foundation for examining the reciprocal relationship between student outcomes and leader development within SI programs.

Hypotheses

H1: SI Leaders at an HBCU who report higher perceived professional development will also report higher perceived student learning outcomes.

H2: The relationship between SI Leader professional development and perceived student learning outcomes will be moderated by perceptions of program logistics.

H3: SI Leaders at an HBCU will report stronger relational and identity-based dimensions of leadership than those documented in prior studies conducted at PWIs or other MSIs.

H4: SI Leader perceptions will complement prior findings on SI participants, suggesting that SI operates as a reciprocal model supporting both academic outcomes and leadership development.

RESEARCH METHOD

Setting and Participants

This study was conducted at a mid-sized Historically Black College or University (HBCU) located in the mid-Atlantic region of the United States. The institution serves a diverse undergraduate population and is designated as a high-research, minority-serving university. The Supplemental Instruction (SI) program examined in this study was implemented as part of a campus-wide STEM student success initiative previously examined by Brown and Winborne (2025), which demonstrated significant academic benefits for SI participants.

The study focused undergraduate SI Leaders who facilitated peer-learning sessions in introductory biology, chemistry, and mathematics courses during the COVID-19 pandemic (Spring 2021–Fall 2021). During this period, all SI sessions were conducted virtually using video-conferencing platforms (e.g., Zoom or Microsoft Teams) in accordance with institutional health and safety protocols.

Participant Eligibility and Recruitment

Participants were eligible for inclusion if they served as SI Leaders during the specified academic terms and facilitated virtual SI sessions in STEM gateway courses. A census sampling approach was used, in which all SI Leaders affiliated with the program during the study period were invited to participate in the evaluation.

Recruitment was conducted via institutional email at the conclusion of the academic semester. The recruitment message described the purpose of the study, emphasized voluntary participation, and included a link to the online survey instrument. Participation was not tied to program evaluation or employment status, and no incentives were provided.

Consent and data Collection

Prior to accessing the survey, participants were presented with an electronic informed consent form outlining the purpose of the study, procedures, confidentiality protections, and their right to withdraw at any time. Only individuals who provided consent were permitted to proceed.

Data were collected using the Supplemental Instruction Leader Views and Perceptions (SILVP) Inventory, a structured survey instrument consisting of both Likert-type and open-ended items. The survey was administered electronically and completed asynchronously by participants outside of instructional time.

A total of ten SI Leaders (N = 10) completed the survey, representing the full cohort of eligible participants during the study period.

Instrument

To assess Supplemental Instruction (SI) Leaders' perceptions of program effectiveness, professional development, and participant learning outcomes, the study utilized the Supplemental Instruction Leader Views and Perceptions (SILVP) Inventory (Winborne, 2020). The SILVP is a self-administered instrument developed in collaboration with the Supplemental Instruction Program at Morgan State University as part of an ongoing program evaluation initiative.

The instrument consists of 18 Likert-type items organized into three subscales: (a) Participant Learning Outcomes (6 items), (b) SI Leader Professional Development (6 items), and (c) Program Logistics (6 items). All items are measured on a 5-point Likert scale ranging from 1 (*Strongly Disagree*) to 5 (*Strongly Agree*). Subscale scores are calculated by averaging item responses within each domain, with higher scores indicating more positive perceptions.

The SILVP Inventory was designed to capture SI Leaders' experiences during the transition to virtual instruction and has been used as part of institutional assessment practices. Internal consistency reliability for the subscales was evaluated in the present study using Cronbach's alpha coefficients (see Results section).

Participant Learning Outcomes Subscale. The Participant Learning Outcomes subscale assesses SI Leaders' perceptions of the extent to which SI participation supports student academic success. Items within this subscale evaluate perceived improvements in study strategies, critical thinking, engagement, and overall academic performance.

SI Leader Professional Development Subscale. The SI Leader Professional Development subscale measures perceived gains in academic competence, leadership skills, confidence, and awareness of academic and career pathways. This subscale captures the extent to which serving as an SI Leader contributes to personal and professional growth.

Program Logistics Subscale. The Program Logistics subscale evaluates SI Leaders' perceptions of program structure and implementation, including training effectiveness, communication, session organization, and challenges associated with virtual instruction. Items also assess the extent to which logistical factors support or hinder effective SI delivery.

Open-Ended Items. In addition to the Likert-type items, the SILVP Inventory includes open-ended response prompts within each subscale to capture qualitative feedback. These prompts allow SI Leaders to elaborate on their experiences, providing contextual insight into perceived strengths, challenges, and areas for program improvement.

Administration and Data Handling. The SILVP Inventory was distributed electronically to SI Leaders at the conclusion of the academic term. Responses were collected anonymously and treated as confidential. No personally identifying information was collected as part of the instrument.

Procedure

At the conclusion of the academic semester, all Supplemental Instruction (SI) Leaders who had facilitated virtual SI sessions were invited to participate in the study. Recruitment occurred through institutional email using a standardized message that described the purpose of the study, emphasized voluntary participation, and included a secure link to the online survey. Prior to accessing the instrument, participants were presented with an electronic informed consent form outlining the study procedures, confidentiality protections, potential risks, and the option to discontinue participation at any time. Only individuals who affirmed consent were granted access to the survey.

The SI Leader Virtual Perceptions (SILVP) Inventory was administered asynchronously using an online survey platform approved by the institution's Institutional Review Board (IRB). Participants completed the survey at their own pace outside of instructional hours to minimize disruption to academic responsibilities. The SILVP Inventory contained both closed-ended and open-ended items across three domains: (a) perceived impact on student learning, (b) leadership and professional development, and (c) logistical and pedagogical challenges associated with virtual SI delivery. Completion time averaged 15–20 minutes.

To ensure data integrity, responses were screened for completeness and duplicate submissions. No personally identifying information was collected within the survey instrument, and the dataset was stored on an encrypted, password-protected institutional server accessible only to the research team. All procedures adhered to ethical guidelines for educational research involving human subjects.

Qualitative Coding and Trustworthiness

Qualitative data analysis followed a reflexive thematic analysis approach, allowing for the identification of patterned meanings across SI Leaders' responses. Following initial familiarization with the dataset, the research team conducted open coding to identify discrete units of meaning related to participants' experiences. Codes were then iteratively reviewed and grouped into broader conceptual categories through constant comparison. These categories were refined into overarching themes that reflected shared patterns across responses while maintaining sensitivity to variation in individual experiences.

Theme development was both inductive and theoretically informed, with themes interpreted in relation to the study's research questions and the conceptual domains of the SILVP Inventory. Rather than serving as purely descriptive labels, themes were analyzed as representations of underlying processes related to SI Leader development, student learning, and the contextual challenges of virtual instruction.

This interpretive approach allowed the analysis to extend beyond surface-level description to explain how and why SI Leaders experienced particular outcomes.
To enhance trustworthiness, several strategies were employed. Credibility was supported through prolonged engagement with the data and iterative review of codes and themes. Dependability was addressed through collaborative coding and documentation of analytic decisions across the research process. Confirmability was strengthened by maintaining an audit trail of coding revisions and thematic development. Transferability was supported through the use of rich, representative excerpts that allow readers to assess the applicability of findings to similar contexts.

Coding discrepancies were discussed among members of the research team until consensus was reached, ensuring consistency in interpretation while preserving reflexivity in the analytic process.

Data Analysis

Quantitative Analysis

Quantitative data from the SILVP Inventory were exported from the survey platform into *IBM SPSS Statistics* (Version 29.0.1.0; IBM Corp., Armonk, NY) for analysis. Initial data screening procedures included examining missing data, assessing distributional properties, and verifying completeness of scale-level responses. Descriptive statistics, including means and standard deviations, were computed for all items and subscales.
Internal consistency reliability for the SILVP Inventory subscales was evaluated using Cronbach's alpha coefficients to assess the stability of the constructs. Subscale scores were analyzed to characterize SI Leaders' perceptions related to participant learning outcomes, professional development, and program logistics. Given the exploratory nature of the study and the modest sample size, analyses focused on descriptive trends rather than inferential statistical testing.

Qualitative Analysis

Qualitative responses to open-ended survey items were analyzed using reflexive thematic analysis as outlined by Virginia Braun and Victoria Clarke (2006, 2019). This approach was selected for its flexibility in identifying patterns of meaning within participants' experiences while allowing for interpretive depth.
Qualitative data were organized and managed using *NVivo* (Version 15.3; QSR International). NVivo was used to facilitate data organization, coding, and retrieval; however, all coding and thematic development were conducted by the research team. The analytic process followed Braun and Clarke's six-phase framework:

1. Familiarization – All responses were read in full to develop an overall understanding of the dataset.
2. Initial Coding – Open coding was conducted to identify meaningful units of text reflecting SI Leaders' perceptions and experiences.
3. Theme Development – Codes were examined and grouped into broader categories representing patterned responses.
4. Review of Themes – Emerging themes were refined through iterative comparison across responses to ensure internal coherence and distinctiveness.
5. Defining and Naming Themes – Themes were clearly defined and aligned with the conceptual domains of the SILVP Inventory.
6. Reporting – Representative excerpts were selected to illustrate key themes.

Themes reflected core domains such as perceived student learning, leadership development, and challenges associated with virtual SI delivery. To enhance analytic rigor, coding decisions were reviewed collaboratively by members of the research team, and discrepancies were resolved through discussion and consensus.

Integration and Triangulation

Consistent with a convergent mixed-methods design, quantitative and qualitative findings were integrated during interpretation to generate meta-inferences. Triangulation was used to strengthen credibility by examining areas of convergence and divergence across datasets. Convergent findings reinforced patterns observed in SI Leaders' perceptions, while divergent findings provided insight into contextual factors influencing their experiences.

This integrated analytic approach enabled a more comprehensive understanding of SI Leader development and student learning within the context of virtual Supplemental Instruction at a Historically Black College or University.

RESULTS

This study employed a convergent mixed-methods design in which quantitative and qualitative data were collected concurrently, analyzed independently, and then integrated to provide a comprehensive understanding of Supplemental Instruction (SI) Leader experiences. In accordance with this design, quantitative findings are presented first to establish overall trends in SI Leaders' perceptions of student learning, professional development, and program logistics. Qualitative findings are then presented to contextualize and elaborate these patterns. Finally, an integrated analysis synthesizes both strands to generate meta-inferences regarding the reciprocal and contextually grounded nature of SI leadership at a Historically Black College or University.

Quantitative Findings

Descriptive analyses of the SILVP Inventory revealed distinct patterns across the three domains of Participant Learning Outcomes, SI Leader Professional Development, and Program Logistics. Descriptive statistics for each SILVP Inventory subscale are presented in Table 1.

Table 1

Descriptive Statistics for SILVP Inventory Subscales

Subscale	Mean	SD	Range (%)
Participant Learning Outcomes	8.25	1.23	5.83–10
SI Leader Professional Development	5.40	0.73	4.0-6.67
Program Logistics	5.12	1.24	3.67–7.33

Note. Scores are based on a 10-point Likert -type scale, with higher values indicating more positive perceptions. Higher scores reflect more positive perceptions.

Figure 1 visually compares the mean scores for each SILVP Inventory subscale relative to their highest possible values.

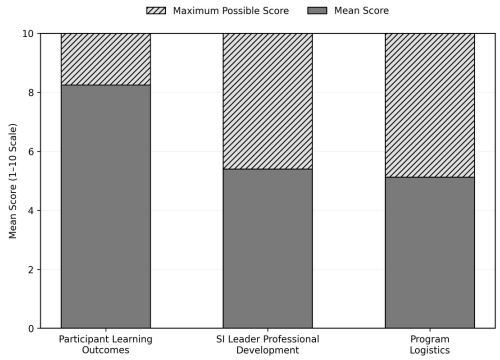

Figure 1. *Mean Scores Across SILVP Inventory Subscales Compared to the Maximum Possible Score.* Note: Scores are based on a 10-point scale, with higher values indicating more positive perceptions. The hatched bars represent the maximum possible score for each subscale, and the solid bars represent observed mean scores.

As shown in Figure 1, SI Leaders reported the highest perceived effectiveness in Participant Learning Outcomes relative to the other SILVP domains, followed by moderate perceptions of SI Leader Professional Development and more variable perceptions of Program Logistics.

Participant Learning Outcomes

Participant Learning Outcomes emerged as the highest-rated subscale, reflecting SI Leaders' perceptions that students experienced meaningful academic gains through SI participation. The highest-rated items included positive participant feedback (M = 9.3), increased critical-thinking abilities (M = 8.4), and improved study skills associated with regular attendance (M = 8.4).

These findings indicate that SI Leaders perceived their instructional efforts as effective in supporting student learning and align with H4, which predicted that SI Leader perceptions would complement prior evidence of participant academic gains at the same institution.

SI Leader Professional Development

The SI Leader Professional Development subscale reflected moderate perceived gains (M = 5.4, SD = 0.73). SI Leaders reported improvements in academic knowledge (M = 7.9), increased awareness of STEM career pathways (M = 7.8), and minimal interference with their own academic performance (M = 7.7).

These findings suggest that SI leadership contributes to meaningful, though variable, professional and academic development. The observed co-occurrence of leader development and student learning perceptions supports H1 and is consistent with a reciprocal model of development.

Program Logistics

Program Logistics yielded the lowest mean score (M = 5.12, SD = 1.24), reflecting more mixed perceptions of the operational and technological aspects of the SI program in a virtual environment. While leaders rated training positively (M = 8.6), they reported lower confidence in aspects related to virtual delivery and engagement (M = 7.0).

These findings support H2, indicating that program logistics may moderate the relationship between SI Leader development and perceived student learning. Although SI Leaders continued to report strong perceptions of student learning, logistical constraints appeared to influence their overall instructional experience.

Summary of Quantitative Trends

Taken together, the quantitative findings reveal a pattern in which strong perceptions of student learning co-occur with moderate leader development and more variable perceptions of program logistics. This pattern provides an empirical foundation for understanding SI as a potentially reciprocal model of student and leader development and informs the qualitative findings presented below.

Qualitative Findings

Qualitative analysis of open-ended responses yielded three interrelated themes: (1) perceived student learning and engagement, (2) professional and leadership development, and (3) program logistics and virtual delivery.

Theme 1: Perceived Student Learning and Engagement

SI Leaders consistently described improvements in student comprehension, confidence, and participation. For example:

> "I have seen marked improvement in my students' performance and participation since the beginning of SI sessions."

These findings align with the quantitative results, which indicated that Participant Learning Outcomes was the highest-rated SILVP subscale.

At the same time, leaders noted declines in student motivation later in the semester, often attributing this to virtual fatigue and reduced peer interaction.

Theme 2: Professional and Leadership Development

SI Leaders reported growth in communication, time management, and academic confidence:

> "Working in the SI Program has allowed me to have better time-management and critical-thinking skills in my own classes."

Leaders also described developing leadership identities grounded in mentorship, empathy, and peer support, indicating that SI leadership extends beyond instructional delivery to include identity and professional development.

Theme 3: Program Logistics and Virtual Delivery

Consistent with the quantitative results for Program Logistics, which reflected more mixed perceptions, SI Leaders reported challenges related to technology, engagement, and maintaining interaction in virtual environments. While training was viewed positively, leaders identified a need for more targeted preparation in virtual pedagogy.

Mixed-Methods Integration (Meta-Inferences)

The integration of quantitative and qualitative findings provides a more comprehensive understanding of SI Leader experiences than either strand alone. Convergent evidence indicates that strong perceptions of student learning co-occur with meaningful, though more moderate, gains in leader development. Qualitative findings clarify that these outcomes are linked through the process of facilitating peer learning, which promotes both instructional effectiveness and leader growth.

At the same time, divergence across strands highlights contextual constraints. While quantitative findings suggest consistently strong perceptions of student learning, qualitative data reveal challenges related to engagement and virtual interaction that shape leaders' experiences. This suggests that student learning outcomes may be relatively robust across delivery conditions, whereas leader development is more sensitive to program structure and support.

Collectively, these meta-inferences support all four hypotheses while extending their interpretation by demonstrating that SI operates as a reciprocal and contextually mediated system within the HBCU environment.

DISCUSSION AND CONCLUSIONS

This study examined Supplemental Instruction (SI) Leaders' perceptions of student learning, their own professional development, and the logistical challenges associated with virtual SI delivery at an HBCU during the COVID-19 pandemic. Taken together, the mixed-methods findings extend prior work by demonstrating not only positive academic outcomes for participants, but also meaningful developmental gains among SI Leaders. More importantly, the integration of quantitative and qualitative results provides insight into the mechanisms through which these outcomes are co-produced within a culturally affirming learning environment.

The convergence of findings across data sources suggests that SI operates as a relational and developmental system rather than a unidirectional instructional intervention. While quantitative trends indicated strong perceived student learning alongside moderate gains in leader development, qualitative narratives clarified how these outcomes are interconnected through processes of peer instruction, reflection, and mentorship. SI Leaders described how facilitating sessions deepened their own content mastery, strengthened communication skills, and enhanced confidence—demonstrating that teaching itself functioned as a mechanism for learning. These findings align with social constructivist theory, which emphasizes that knowledge is co-constructed through interaction (Lev Vygotsky, 1978; Ann Brown Palincsar, 1998), as well as experiential learning

theory, in which learning emerges through cycles of experience and reflection (David A. Kolb, 1984; Kolb & Kolb, 2005).

The relationship between SI Leader development and perceived student learning appears to be mutually reinforcing rather than linear. As leaders grow in competence and confidence, they create more effective and responsive learning environments, which in turn reinforce their own development. Qualitative evidence further clarifies this dynamic, as leaders reported increased metacognitive awareness and academic self-efficacy as a direct result of facilitating peer learning. This reciprocal process reflects core principles of experiential learning and supports prior research demonstrating that peer-led instruction enhances both cognitive and professional outcomes (Hoiland et al., 2021a). Thus, SI leadership functions not only as an instructional role but also as a developmental mechanism through which leaders consolidate knowledge, refine skills, and construct professional identity.

At the same time, program logistics emerged as a constraining factor that shaped, but did not negate, these outcomes. Challenges associated with virtual delivery—including reduced engagement, inconsistent attendance, and technological barriers—limited leaders' sense of instructional effectiveness and professional growth. Notably, this divergence suggests that student learning gains may be relatively resilient to delivery challenges, whereas leader development is more sensitive to environmental structure and program design. This asymmetry highlights the importance of intentional training in digital pedagogy, structured mentorship, and institutional support systems to sustain leader development in virtual or hybrid contexts.

The findings also illuminate the culturally grounded nature of SI leadership within the HBCU context. SI Leaders consistently described their roles in terms of mentorship, empathy, shared identity, and communal responsibility—dimensions that extend beyond traditional conceptions of peer instruction. These relational and identity-centered practices align with research highlighting the role of culturally affirming environments in supporting persistence and leadership among underrepresented STEM students (Achat-Mendes et al., 2022; Anfuso et al., 2022). Within this context, SI leadership functions not only as an academic intervention but also as a space for belonging, identity development, and community engagement. This cultural grounding appears to amplify both student and leader outcomes, underscoring the importance of institutional context in shaping the effectiveness of peer-led learning models.

Building on these findings, this study advances a conceptual double-impact model of Supplemental Instruction at HBCUs. As illustrated in Figure 2, this model

positions SI as a bidirectional developmental system in which student learning outcomes and leader professional identity formation are co-constructed through structured peer engagement. Unlike traditional SI frameworks that emphasize participant outcomes alone, the double-impact model foregrounds leadership development as an equally central and intentional outcome. Grounded in social constructivist and experiential learning theories, this model conceptualizes SI sessions as dynamic environments where teaching, learning, and identity formation occur simultaneously. Within HBCU contexts, this process is further enriched by culturally responsive practices that emphasize mentorship, relational engagement, and collective success.

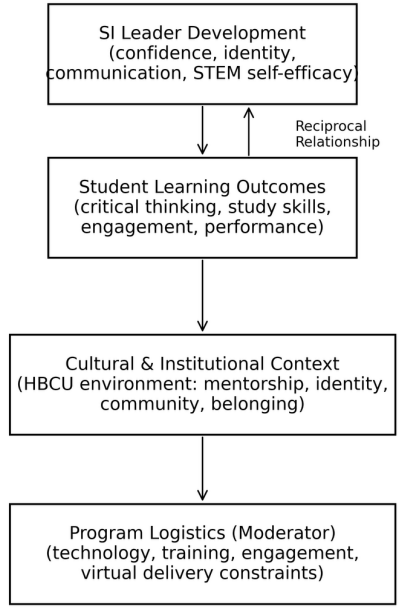

Figure 2. *Conceptual Double-Impact Model of Supplemental Instruction at an HBCU.* Note: The model illustrates the reciprocal relationship between SI Leader development and student learning outcomes, shaped by cultural and institutional context and moderated by program logistics.

Importantly, the double-impact model represents a conceptual contribution that extends beyond the present study. It offers a transferable framework for understanding how peer-led academic support programs can be intentionally designed to promote both student success and leadership development, particularly

among historically underrepresented populations in STEM. This model may be especially relevant for Minority-Serving Institutions seeking to integrate academic support with workforce preparation, identity development, and inclusive excellence.

Despite these contributions, the study has several limitations. The small sample size and single-institution context limit generalizability, and the reliance on self-reported perceptions introduces the potential for response bias. Additionally, the study was conducted during a period of emergency remote instruction, and some findings may reflect pandemic-specific conditions rather than stable features of SI programming. Future research should include multi-institutional samples, incorporate longitudinal designs to examine leadership trajectories over time, and integrate additional data sources such as student performance outcomes, observational data, and faculty assessments.

Overall, the findings demonstrate that Supplemental Instruction at an HBCU operates as a culturally responsive, developmentally meaningful, and academically impactful practice. SI Leaders emerge not only as facilitators of peer learning but also as developing professionals whose growth is shaped through teaching, reflection, and community engagement. By advancing the double-impact model, this study contributes a theoretically grounded and transferable framework for understanding how peer-led academic support can simultaneously promote learning, leadership, and identity development in STEM education.

IMPLICATIONS

Building on the double-impact model proposed in this study, the following implications translate these findings into actionable strategies for program design, institutional practice, pedagogy, and future research. Collectively, these recommendations position Supplemental Instruction (SI) not only as an academic support mechanism, but as an integrated framework for leadership development and student success.

Programmatic Implications

Findings suggest that SI programs should be intentionally designed to support both student learning outcomes and SI Leader development as co-equal objectives. Consistent with the double-impact model, program structures should incorporate deliberate opportunities for leaders to engage in reflection, mentorship, and skill-building alongside instructional responsibilities. This may include structured reflective journals, peer debrief sessions, and leadership-focused training modules that reinforce communication, facilitation, and metacognitive skills.

Additionally, training programs should be expanded to include targeted preparation in digital pedagogy and student engagement strategies, particularly in virtual or hybrid environments. While SI Leaders demonstrated adaptability under constrained conditions, their experiences indicate that leader development is highly sensitive to program design and support. Embedding leadership development intentionally within SI programming can enhance both leader outcomes and the quality of peer instruction delivered to students.

Institutional Implications

For HBCUs and other Minority-Serving Institutions, SI represents a strategic opportunity to integrate academic support with leadership development, identity formation, and workforce readiness. The double-impact model positions SI as a scalable mechanism for cultivating student leaders who are not only academically proficient but also equipped with transferable professional skills.

Institutions may consider formalizing SI leadership as a recognized high-impact practice through mechanisms such as micro-credentials, co-curricular transcripts, or integration with undergraduate research and professional development pathways. Aligning SI with broader institutional priorities—such as STEM persistence, career readiness, and graduate school preparation—can further enhance its impact and sustainability.

Moreover, the culturally affirming dimensions of SI observed in this study highlight the importance of maintaining and leveraging institutional context. Practices rooted in mentorship, community, and shared identity should be intentionally preserved and amplified, as they appear to strengthen both student engagement and leader development.

Pedagogical Implications

The findings underscore the importance of designing SI sessions as interactive, student-centered learning environments that extend beyond content review to include collaborative problem-solving, discussion, and peer engagement. SI Leaders should be equipped with pedagogical strategies that promote active learning, foster critical thinking, and sustain motivation—particularly in virtual settings where engagement may be more difficult to maintain.

Training should emphasize the integration of relational pedagogy with instructional techniques, enabling leaders to build trust, encourage participation, and support diverse learners effectively. The persistence of strong perceived student learning outcomes despite logistical challenges suggests that pedagogical quality plays a critical role in the success of SI, even under suboptimal conditions.

Institutions should also consider maintaining hybrid or flexible SI delivery models, as these may expand access for students balancing academic, work, and caregiving responsibilities while preserving opportunities for meaningful peer interaction.

Research Implications

This study advances the double-impact model as a conceptual framework for understanding SI as a bidirectional developmental system. Future research should test and refine this model across institutional contexts, including Predominantly White Institutions and other Minority-Serving Institutions, to assess its generalizability and identify context-specific dynamics.

Longitudinal studies are particularly needed to examine how SI leadership experiences influence academic trajectories, career outcomes, and STEM identity development over time. Additionally, incorporating multiple data sources—such as direct measures of student performance, observational data, and faculty evaluations—would strengthen the evidence base and provide a more comprehensive understanding of SI's impact.

Comparative research across instructional modalities (in-person, hybrid, and virtual) would further clarify the conditions under which both student learning and leader development are optimized. Such work would contribute to a more nuanced understanding of how program design, institutional context, and delivery format interact within the double-impact model.

LIMITATIONS AND FUTURE DIRECTIONS

This study has several limitations that should be considered when interpreting the findings. The small sample size (N = 10) and single-institution HBCU context limit the generalizability of results. While the study offers important insights into SI Leader experiences within a culturally affirming environment, the extent to which these findings translate to other institutional contexts remains uncertain. Additionally, the reliance on self-reported perceptions introduces the potential for response bias, as participants may overestimate or underestimate their experiences and outcomes.

The study was also conducted during a period of emergency remote instruction prompted by the COVID-19 pandemic. As a result, factors such as technological barriers, reduced interpersonal interaction, and virtual fatigue may have influenced both leader perceptions and student engagement. Some observed patterns—particularly those related to program logistics—may therefore reflect context-specific conditions rather than stable features of Supplemental Instruction programming.

Future research should extend this work by examining the double-impact model across multiple institutional contexts, including Predominantly White Institutions and other Minority-Serving Institutions, to assess its generalizability and identify context-specific mechanisms. Longitudinal studies are needed to track SI Leader development over time and to evaluate how leadership experiences influence academic trajectories, career outcomes, and STEM identity formation.

Additionally, future studies should incorporate multiple data sources, including direct measures of student academic performance, observational data of SI sessions, and faculty assessments, to complement self-reported perceptions. Comparative analyses across instructional modalities—face-to-face, hybrid, and virtual—would further clarify the conditions under which both student learning and leader development are optimized. Such work will be critical for refining the double-impact model and advancing understanding of how peer-led learning environments can be designed to support both academic success and leadership development in STEM education.

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