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Building Empowerment-Based Learning and Community-Rooted Leadership in Pre-College Engineering Education: A Narrative Case Study of Legacy in Urban STEM Pathways

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Abstract

This narrative case study illuminates the transformative impact of African American community-rooted leadership in expanding pre-college engineering opportunities for urban youth. Centered on the life work of Kenneth Hill, engineer, educator, and founder of the Detroit Area Pre-College Engineering Program (DAPCEP) and the Chicago Pre-College Science and Engineering Program (ChiS&E), the study examines how asset-based pedagogy [1], [2], empowerment-based learning [3], [4], and community-rooted leadership [5] cultivated enduring systems of support for students who have not traditionally been represented in engineering pathways.

Using a qualitative case study methodology grounded in extensive interviews and archival analysis, this work blends scholarly analysis with narrative storytelling to examine the human, political, and pedagogical dimensions of educational transformation. Findings reveal that Hill's leadership redefined not only what students could achieve, but what communities came to expect of themselves, generating a culture of engineering possibility that persists across decades. The study contributes a rare, voice-centered account of equity-oriented leadership in engineering education and offers an alternative model for designing sustainable, community-driven STEM ecosystems.

Keywords: educational leadership; community engagement; empowerment-based learning; pre-college engineering programs; asset-based pedagogy; urban education; aspirational pedagogy

I. Introduction: Educational failure is structural rather than cognitive

"This story has to start in Zambia," Kenneth Hill begins, almost abruptly, when asked about the origins of his life's work. Not Detroit. Not Chicago. Not a university boardroom or foundation office. But Zambia. Hill recalls standing in a classroom "in the Bush," teaching calculus and physics to students nearly a thousand miles from the capital city. What struck him was not deprivation, but precision: "They had nine hours of math starting in the 7th grade every week… I'm teaching two hours a day back home!"

There was no mythology of natural ability; there was only time, structure, and expectation. Students stood when he entered the room. He observed that students thrived when time-on-task and expectations were high, leading him to conclude that educational failure was structural rather than cognitive. This insight became foundational to his work in pre-college engineering education in large, urban-centered settings. Here, though, there were no behavioral battles, no

technological distractions, and no presumption that a content area such as calculus was beyond them. They simply did the work.

When Hill returned to the United States and heard colleagues casually say that African American students "can't handle math," he remembers thinking: "We've been brainwashed."

This realization, that failure was structural, not cognitive, became the animating force behind what would become one of the longest-running, community-rooted pre-college engineering pipelines in the country. This case study explores how Hill, alongside his colleagues at DAPCEP and ChiS&E, turned that insight into enduring institutions by combining asset-based pedagogy, empowerment-driven learning, and community-rooted leadership in ways that continue to influence pre-engineering education in large, urban-centered settings.

II. Methods: A Narrative Case Study

Methodology

This study employs a qualitative, embedded single-case design to examine the leadership philosophy and educational practice of Kenneth Hill, a long-serving community-based engineering education leader whose work spans multiple decades and institutional contexts. A case study approach was selected because the purpose of this inquiry is not to generalize across populations, but to generate a rich, contextualized understanding of how leadership, pedagogy, and community engagement evolve over time within a single, influential practitioner's career [7]. Case study methodology is particularly appropriate for examining complex social phenomena that are deeply embedded in historical, organizational, and cultural contexts and cannot be meaningfully separated from them [8], [9].

The case is structured as an embedded design, focusing on two major initiatives that represent distinct phases of Hill's leadership trajectory: DAPCEP in Detroit (1976–2002) and ChiS&E in Chicago (2008–present). These two initiatives serve as analytic subunits within the broader case, allowing for examination of continuity and adaptation in leadership practice across institutional settings, historical moments, and community contexts [7]. This design supports both within-case analysis and cross-phase comparison, illuminating how core philosophical commitments were sustained while program structures and strategies evolved.

To clarify how the analysis unfolded and to stay grounded in the lived experiences and stories shared throughout this case, the study was guided by two overarching research questions. These questions reflect both a close reading of Hill's life-course work and an effort to understand how those experiences took shape across different programs, moments, and community contexts.

RQ1: How are asset-based pedagogy, empowerment-based learning, and community-rooted leadership enacted in Kenneth Hill's presented life-course work across different programs and urban-centered contexts?

RQ2: How do these practices influence program design, community engagement, and the long-term sustainability of STEM pathways in urban-centered settings?

Data Sources and Collection

Data were drawn from four primary sources: (a) in-depth semi-structured interviews with Hill, (b) archival program records, (c) historical evaluations and funding documentation, and (d) the researcher's long-standing professional engagement with the programs and their leadership. The use of multiple data sources was intended to strengthen construct validity through triangulation and to capture both retrospective narrative and contemporaneous documentation of program design and outcomes [10], [7].

The primary data source consisted of two extensive semi-structured interviews with Hill, totaling approximately three hours of recorded dialogue. Semi-structured interviewing was selected to balance analytic focus with narrative openness, allowing the participant to reflect in depth on formative experiences, leadership decisions, and program design while ensuring systematic coverage of core thematic domains [11]. This approach is particularly well suited to leadership and life-history research, where meaning is constructed through reflection on experience rather than through brief or highly structured questioning [12].

Interview protocols were organized around three broad domains: (1) formative experiences and early leadership development; (2) program design and pedagogical philosophy; and (3) community relationships, institutional negotiation, and long-term impact. Within each domain, open-ended prompts encouraged narrative elaboration, followed by probing questions to clarify decisions, contextual influences, and perceived consequences. This design aligns with narrative interviewing traditions that emphasize temporality, identity construction, and sense-making across the life course [13].

Archival sources included program proposals, annual reports, internal evaluations, funding histories, and curriculum materials spanning both initiatives. These materials provided institutional context, documented program evolution, and enabled verification of timelines and organizational claims. In addition, the researcher's long-standing professional engagement with Hill and both programs provided a supplementary interpretive lens. Such engagement is recognized as a legitimate form of experiential data in qualitative case study and practitioner research [8], [7].

Analytic Approach

Analysis followed a narrative–thematic approach designed to preserve participant voice while systematically examining leadership practices, pedagogical design principles, and community engagement strategies. Interviews were transcribed verbatim and analyzed iteratively using a combination of narrative analysis and thematic coding [13], [14]. Initial coding focused on descriptive categories related to leadership actions, program structures, community relationships, and institutional negotiations. Subsequent analytic cycles identified higher-order themes connected to asset-based pedagogy, empowerment-based learning, and community-rooted leadership. Throughout the analysis, particular attention was paid to maintaining the integrity of Hill's narrative voice. Rather than fragmenting accounts into decontextualized codes, extended quotations were preserved and analyzed as coherent meaning units, consistent with narrative case study traditions that privilege temporality, coherence, and identity construction [13],[8].

Analytic memos documented emerging interpretations, connections to theoretical frameworks, and reflexive considerations related to the researcher's positionality and prior engagement with the case.

Trustworthiness and Rigor

Several strategies were employed to enhance the study's trustworthiness. Data triangulation across interviews, archival materials, and institutional records supported credibility by corroborating key events and program features [10]. Prolonged engagement and persistent observation strengthened contextual understanding and enabled nuanced interpretation of leadership practices over time [15]. Reflection was conducted informally through follow-up conversations with the interviewee (Hill) to clarify interpretations and verify the accuracy of reconstructed timelines and program descriptions.

III. The Intervention Programs: DAPCEP and CHiS&E

The Detroit Area Pre-College Engineering Program (DAPCEP)

DAPCEP was founded in 1976 by Kenneth Hill, represents one of the earliest and most sustained models of pre-college engineering pathway development in the United States. Emerging from university–community partnerships in Detroit, DAPCEP was designed as a long-term intervention to strengthen mathematics preparation, expand access to engineering and science careers, and address persistent inequities in opportunity [16], [17]. Rather than functioning as a short-term enrichment program, DAPCEP established a multi-year engagement structure through Saturday academies, summer programs, and sustained mentoring, grounded in strong collaborations with higher education institutions and industry partners [16], [18]. Over time, the program has scaled significantly, now serving thousands of students annually, while maintaining its core emphasis on continuity, academic rigor, and career exposure [21]. Its enduring contribution lies in its structured pathway model, which integrates early exposure, repeated participation, and institutional connection to support students' progression into STEM fields.

The Chicago Pre-College Science and Engineering Program (ChiS&E)

ChiS&E was founded in 2008 by Kenneth Hill, built on the DAPCEP model, and extended its reach to earlier grade levels, placing greater emphasis on family engagement. Designed as a longitudinal pathway beginning as early as kindergarten, ChiS&E combines mathematics-focused instruction, hands-on STEM learning, and sustained participation across the K–12 spectrum [22]. A defining feature of the program is its integration of parents and caregivers as active participants in the learning process, reinforcing academic development and college awareness within the home [20], [22]. Through school-year and summer programming, mentorship, and partnerships with universities and community organizations, ChiS&E has developed a scaffolded model that supports both academic skill-building and identity development over time. The program's continued growth and documented reach reflect its commitment to early engagement, continuity, and family-centered approaches to STEM preparation [22].

Shared Academic and Community Mechanisms

Together, DAPCEP and ChiS&E reflect a unified approach that blends sustained academic preparation with community-rooted supports, demonstrating that effective models must be responsive to the specific career preparation needs of the communities they serve. Although both programs operate in large urban-centered settings and engage similar participant populations, ChiS&E was not simply a replication of DAPCEP transplanted into a new context; rather, each program was intentionally designed to align with local conditions, opportunities, and expectations around STEM pathways. Both emphasize sustained engagement, structured progression, and exposure to authentic STEM contexts through institutional partnerships [17], [18], [21], while also cultivating belonging and persistence through mentoring, community connection, and, in the case of ChiS&E, active family participation [20], [22]. Recent research further reinforces the academic value of such models, with evidence showing that summer pre-engineering experiences can significantly increase students' confidence, motivation, and interest in STEM, particularly among middle school students in large urban centers [23], [24]. This alignment between academic design, community context, and demonstrated outcomes underscores how rigorous, relationship-driven models can be both transferable and locally responsive, supporting meaningful participation in STEM pathways.

IV. Theoretical Framing: From Deficit to Design

Asset-Based Pedagogy: "Our Children Are Brilliant"

Asset-based pedagogy rejects narratives that frame marginalized students as deficient and instead centers cultural wealth, resilience, and intellectual capacity [1], [2]. What distinguishes Mr. Hill's work is not only that it aligns with this perspective, but that his entire philosophy pivots on it as a lived conviction rather than an abstract framework. "Our children are brilliant and can handle this," he stated often, not as a hopeful claim but as an empirical one, grounded in decades of observation across cultural and institutional settings.

Hill did not romanticize poverty, nor did he deny the realities of structural inequality. He spoke candidly about under-resourced schools, constrained opportunities, and the uneven distribution of educational access. At the same time, he categorically rejected explanations rooted in ability. "The issue was never whether they were capable," he explained. "The real question is whether we've created spaces where that ability can show up." For Hill, inequity was not a reflection of student limitation but of institutional design. "If students aren't succeeding," he often remarked, "that tells you something about the system, not about the child."

This orientation shaped every layer of his practice. Recruitment was direct and personal. Rather than waiting for students to self-select, Hill sought them out. "I want to see you in the program," he would tell prospective participants, signaling not only invitation but expectation. Such moments were deliberate acts of repositioning, placing students not at the margins of opportunity but squarely at its center. Parents, in turn, were not treated as passive recipients of programming but as collaborators with strategic insight. "They know their children better than any test score ever will," Hill insisted. Family histories, aspirations, and everyday problem-solving practices

were incorporated into program design, reinforcing the belief that learning extended far beyond institutional boundaries.

Engineering itself was also reframed. Hill resisted portrayals of the field as rarefied or inaccessible. “Engineering belongs to them already,” he would say. “They’ve been engineering their whole lives.” In neighborhood repair work, household improvisation, and community organizing, he saw the same habits of mind celebrated in formal engineering education, such as design, iteration, systems thinking, and resilience. His programs were built to make those connections visible, legitimate, and valued.

In this way, Hill enacted asset-based pedagogy not as a theoretical stance but as an organizing principle. Like Moll et al.’s [1] families, he treated homes and communities as primary sites of knowledge. Like Yosso [2], he recognized aspiration, navigation, and resistance as central forms of cultural wealth. Yet his framing moved beyond compensation or remediation. He did not seek to fix students; he sought to fix environments. “The intelligence is already there,” he often reminded colleagues. “Our job is to stop building systems that hide it.”

Through this lens, equity became less about access alone and more about expectation, design, and belonging. Hill’s practice suggests that when institutions begin from an assumption of intellectual abundance, the work of education shifts from remediation toward recognition, from sorting toward cultivation, and from possibility toward responsibility.

Empowerment-Based Learning: Designing for Possibility

Hill’s approach to empowerment-based learning did not emerge solely from formal theory. It took shape in the late 1960s and 1970s, when the Civil Rights Movement shifted from protest to institution-building and communities actively sought ways to use education as a tool for collective advancement. In those years, empowerment was not an abstract concept but a daily practice, rooted in organizing, relationship-building, and redesigning systems that had long excluded some.

Hill came of age in this moment. He had already learned grassroots organizing by doing it. He spoke often of “wearing out my shoes,” moving from church basements to school auditoriums, from neighborhood centers to modest city homes, listening to families and educators as they imagined new futures for their children and students. “We were trying to build something that would last,” he recalled. “Not just programs, but pathways.” Without the language of pedagogy or policy, Hill absorbed a core insight that later echoed Freire’s [3] argument that education must be a practice of freedom rather than a mechanism of sorting.

Hill did not arrive at empowerment through academic study. He arrived through experience, proximity, and respect for communities already redesigning their own systems. “People didn’t need saving,” he reflected. “They needed opportunity, and they needed institutions to stop standing in the way.” This stance closely aligns with Freire’s insistence that learners are historical actors capable of transforming their conditions, and with later work on psychological empowerment that centers agency, competence, and access [4]. When Hill helped launch

DAPCEP's first summer program at a major state university, empowerment took the form of careful design rather than inspirational rhetoric. Students received two hours of algebra daily, structured study halls with university mathematics assistants, low instructor-to-student ratios, and immediate reinforcement when concepts were misunderstood. The architecture of the program reflected a deliberate theory of change: rigor without abandonment, challenge without isolation, support without lowered expectations. Hill described the design simply: "We designed it so that students felt seen, heard, and supported." Beneath this simplicity lies a sophisticated understanding of empowerment as structural access. "Motivation doesn't come first," he often explained. "Success comes first. When students see themselves succeed, then they start believing." Empowerment, in this sense, was not confidence alone but the systematic removal of barriers to high-level learning.

Community-Rooted Leadership: Trust Before Scale

Hill's leadership followed the same logic. He did not begin with institutions or policy frameworks; he began with people. Community-rooted leadership emphasizes relational authority, long-term presence, and moral credibility over positional power [5]. Hill embodied this long before the term existed.

He spoke often of mentors like Mrs. Adams, a respected community leader who combined high expectations with deep relational authority. "She expected parents to support their children," Hill recalled, "and they listened because she had earned that right." From such figures, Hill learned that educational leadership in large, urban-centered settings is built not on titles but on trust developed and sustained over time. This was especially evident during the civil rights era, when power struggles, limited trust in institutions, and a strong reliance on support within one's own community shaped how people worked together and led.

His own practice reflected this lesson. He walked school hallways, attended evening parent meetings, visited homes, and lingered at neighborhood events long after formal sessions ended. "You can't design programs from an office," he insisted. "You have to know how people actually live." Trust, in his view, preceded scale. Programs grew not because they were well-branded, but because families vouched for them, educators defended them, and students returned year after year.

Through this combination of empowerment-based design and community-rooted leadership, Hill built more than programs. He built ecosystems of belief and systems in which young people were not merely invited to participate, but expected to succeed, supported to persist, and trusted to lead.

Empowerment and Identity Development

These design choices did more than improve academic outcomes; they shaped how students came to see themselves. By positioning success as attainable and intelligence as assumed, Hill's programs cultivated what identity scholars describe as a sense of competence, belonging, and

possible selves within STEM. Repeated experiences of mastery, public recognition, and sustained support allowed students to internalize new identities, not as outsiders trying to enter engineering, but as legitimate participants already on that path. In this way, empowerment-based learning functioned not only as access to opportunity, but as identity work: constructing engineers through sustained affirmation and experience.

V. Findings: Where Story Becomes System

The findings are organized to first examine how Hill's leadership practices are enacted over time and across contexts, and then to show how those practices translate into sustained programmatic and community-level outcomes.

RQ1: Enacting Asset-Based Pedagogy, Empowerment-Based Learning, and Community-Rooted Leadership Across Programs and Urban-Centered Contexts

Reengineering Time as Structural Intervention

Hill's leadership trajectory reflects more than a sequence of programs; it represents a life course process of learning, testing, revising, and reimagining what educational empowerment can look like across time and place. He spent more than twenty years building and refining DAPCEP in Detroit and, by 2026, an additional two decades leading ChiS&E in Chicago Across these forty-plus years, his work unfolded not as a fixed model replicated unchanged, but as a living theory of practice with lessons learned, applied, re-examined, and modified in response to shifting political climates, institutional constraints, and community needs. What remains consistent across contexts is not a particular structure, but a set of design commitments grounded in asset-based pedagogy, empowerment-based learning, and identity development.

Hill's earliest structural insight grew directly from this orientation. "Ability isn't the issue," he often remarked. "What matters is how early you give students a real chance to practice being excellent." In this view, preparation was not a matter of talent, but of timing. Consistent with theories of opportunity to learn and time on task [25], [26], Hill understood the importance of instructional minutes and when and how they were distributed, functioning as powerful gatekeeping mechanisms.

In Detroit, this insight became a deliberate intervention. Rather than waiting for high school gatekeeping to determine who belonged in advanced mathematics, DAPCEP introduced algebra during middle school summers, forty years ago; this was many years before most students encountered such topics (usually in high school). "By the time the system decided who was 'ready,'" Hill reflected, "we wanted our students to already know they were." This move embodied the central premise of asset-based pedagogy: readiness is not discovered, but cultivated through access and expectation [1], [2].

DAPCEP did not seek improvement within scarcity. It redesigned the learning ecology itself by expanding instructional time, lowering student-to-teacher ratios, embedding daily tutoring, and providing immediate feedback. Hill described the design plainly: "We built a place where

struggle didn't mean falling behind. It just meant you stayed longer and learned more." In doing so, the program operationalized empowerment as structural access rather than motivational rhetoric, aligning closely with Freire's [3] insistence that liberation begins with material conditions and Zimmerman's [4] framing of empowerment as access to competence and control. Rather than persuading students that they belonged in advanced mathematics, Hill built systems that made belonging routine. "When success becomes normal," he noted, "confidence takes care of itself." Empowerment here was structural first and psychological by consequence: access preceded agency, and design preceded belief.

Parents as Political Architects

Hill's most consequential innovation unfolded beyond the classroom. Long before family engagement became formal policy, he repositioned parents as institutional actors rather than peripheral supporters. The Parent Advisory Committee did not simply organize events. It negotiated with Detroit Public Schools, monitored program continuity, and reshaped district commitments. "They understood something early," Hill recalled. "If you want programs to last, families, as citizens, have to sit at the tables where budgets get decided."

When foundation funding expired, parents secured the district's adoption of the program, transforming DAPCEP from a grant-funded initiative into public infrastructure. This moment illustrates asset-based pedagogy enacted institutionally: recognizing community cultural wealth not symbolically, but structurally [2]. Rather than treating families as beneficiaries, Hill mobilized their navigational and political capital to reshape governance. "The parents weren't asking for favors," he explained. "They were making an argument the system couldn't ignore."

This leadership stance aligns with community-rooted leadership frameworks that privilege relational credibility, long-term presence, and moral authority over positional power [5]. Hill did not substitute his voice for the community's. He amplified it. "My job wasn't to lead them," he noted. "My job was to make sure the system heard them clearly." Empowerment, in this sense, extended from classrooms into the political architecture of schooling.

"We Showed Isaah Another Way": Identity as Outcome

Hill frequently returned to the story of Isaah, a young DAPCEP student from the past, not in celebration but as an analytical anchor. "Isaah had obstacles in his path that influenced his behavior. And Isaah didn't change overnight," he explained. "What changed was that he found another set of doors, and those doors finally stayed open long enough for him to walk through." Despite early academic setbacks, Isaah found new doors that led him to DAPCEP and eventually to academic success. This culminated in elite engineering credentials and industry leadership. But Hill framed this situation not as exceptional talent but as a predictable consequence of redesigned opportunity structures.

From an identity development perspective, Isaah's trajectory reflects the gradual construction of a possible self as an engineer [28] and the consolidation of a disciplinary identity through competence, recognition, and belonging [29]. Repeated experiences of mastery and affirmation

allowed Isaah to internalize an engineering identity before institutions formally certified it. "Once he started saying 'I'm good at this,'" Hill recalled, "everything else started lining up behind that."

Engineering education here functioned as a narrative intervention. The program interrupted an expected social trajectory for "boys like him" and replaced it with a technical future that felt legitimate and attainable. "We weren't just teaching math," Hill reflected. "We were changing what young people thought was allowed to happen in their lives."

Chicago: Same Vision, Different Politics

In Chicago, Hill encountered a more complex institutional terrain. "In Chicago," he observed, "decisions weren't about results. They were about history, alliances, and who had the loudest voice." Despite support from national research organizations and local foundations, long-term engineering pipelines faced resistance within a funding ecosystem that normalized investing in sports, vocational pathways, and violence prevention for inner-city youth, but hesitated to invest in technical or collegiate futures. Hill responded with a redesign rather than retreat. He began the Chicago Pre-College Science and Engineering Program (ChiS&E) for kindergarteners and added one grade upward at a time. This strategy reflected both developmental theory and political pragmatism: identity formation and preparation had to precede institutional sorting [30]. "If students meet engineering after the system has already labeled them," he noted, "you're fighting momentum instead of building it."

RQ2: Influencing Program Design, Community Engagement, and the Long-Term Sustainability of STEM Pathways in Urban-Centered Settings

A Life Course Theory of Empowerment in Practice

Hill's work demonstrates that empowerment is not a single intervention but a longitudinal design problem that requires sustained attention to time, institutional structures, community power, and identity development. His leadership illustrates how asset-based assumptions, when enacted structurally, can reshape classrooms, governance, trajectories, and self-concepts. Hill readily admits the many moments of disappointment and heartbreak he experienced when general support, funding, or even community support wavered. But he persisted. And rather than replicating a fixed model, Hill adapted a stable set of design commitments across contexts as shown in Table 1.

Table 1. Mapping Leadership Practices to Theoretical Constructs

Leadership Practice / Design Feature	Core Design Principle	Theoretical Frame	Illustrative Evidence from Case
STEM for All	STEM & Critical Thinking; Success leads to Motivation	Sociocultural Learning & Identity [28]	Program built starting at Kinder and in large urban contexts before institutional tracking closes doors
Rigorous math and science introduced early	Opportunity precedes accepted readiness timeline	Opportunity to Learn; Asset Based Pedagogy [24], [1]	Algebra introduced years before institutional gatekeeping; leads to pursuit of higher levels of STEM
Extended instructional time and daily tutoring	Structural element put in place to allow access and rigor	Empowerment Theory [4]; Freire [3]	Saturated time, low student-teacher ratios, immediate feedback
Parent Advisory Committee governance	Families are crucial as institutional actors	Community Cultural Wealth [2]; Community Rooted Leadership [5]	Parents secured district adoption and budget commitments
Attending to Longitudinal pipelines from K–12	Identity is cultivated over time	Possible Selves; STEM Identity [28]; [27]	Students internalized engineering identity prior to certification

Brilliance is assumed, opportunity is engineered, families are institutional actors, and identities are cultivated over time. In this sense, his life's work offers not merely a case study of leadership but a generational blueprint for designing educational systems capable of sustaining empowerment across changing political and social landscapes.

VI. Discussion: What This Case Reveals to Engineering Education

Viewed across four decades and two institutional contexts, this case offers a practice-based account of how equity in engineering education is produced through design rather than aspiration. Rather than locating success or failure within individual students or isolated schools, the case redirects analytic attention to the architecture of opportunity, including the timing, intensity, governance, and relational infrastructures that shape preparation, persistence, and belonging [25], [26], [27].

First, the case demonstrates that equity can be engineered. Across Detroit and Chicago, Hill treated preparation as a structural condition rather than a student trait. By redistributing instructional time, introducing advanced content early, and saturating learning environments with support, the programs operationalized opportunity-to-learn principles long emphasized in engineering education research [31], [32]. Equity emerged not from remediation or recruitment alone, but from redesign of learning conditions.

Second, the case reframes families as institutional actors rather than peripheral stakeholders. By positioning parents as negotiators and governance partners, Hill mobilized community cultural wealth to reshape funding commitments and institutional priorities [2], [5]. This dimension challenges dominant engagement models in engineering education that emphasize communication and participation while leaving authority structures unchanged. Here, empowerment operated through governance rather than symbolism.

Third, the case features identity development as a longitudinal outcome of program architecture. Engineering identity was cultivated years before college through repeated experiences of competence, recognition, and belonging. Consistent with research on STEM identity and

persistence [29], [33], students did not become engineers because they were selected; rather, environments allowed them to practice being engineers early and often. Identity development functioned as a design outcome rather than a curricular add-on. Together, these lessons challenge deficit-oriented and pipeline-fragmented models that dominate much of the reform of engineering education. The case suggests that equity is less a matter of motivating students and more a matter of redesigning systems.

VII. Implications for Engineering Education

The implications of this case span program design, leadership preparation, and policy, offering clear guidance for institutions seeking to build sustainable and equitable engineering pathways.

Program Design: Longitudinal, High-Dosage Pathways

First, engineering pathways must begin early and be intentionally designed as longitudinal systems. Developmental and sociocultural research shows that academic trajectories and disciplinary identities consolidate well before formal gatekeeping occurs [30], [34]. For engineering education, this means that interventions introduced only at the high school or college level are unlikely to be sufficient. Instead, early and continuous exposure to rigorous mathematics, problem solving, and engineering practices is essential.

Second, programs should institutionalize high-dosage learning environments. Hill's designs emphasized extended instructional time, low student–teacher ratios, frequent feedback, and sustained tutoring, all of which are associated with improved persistence and conceptual learning in engineering contexts [35], [32]. These findings are reinforced by more recent studies demonstrating that sustained summer and out-of-school STEM experiences significantly increase student confidence, motivation, and interest in engineering pathways, particularly when embedded within broader longitudinal systems [23], [24]. As such, program effectiveness should be measured not by short-term outputs but by sustained engagement and cumulative developmental impact. This remains in tension with funding and institutional structures that prioritize short-term gains, often at the expense of long-term success.

Third, family leadership structures should be formalized within program governance. Moving beyond outreach toward shared authority strengthens accountability, sustainability, and cultural alignment, particularly in communities historically excluded from engineering pathways [2], [27]. Evidence from community-based STEM initiatives further suggests that when families are positioned as partners rather than participants, programs are more likely to sustain engagement and reinforce learning beyond formal instructional settings [36].

Leadership Development: Engineering Leaders as Institutional Designers

At the leadership level, this case underscores that advancing engineering education requires competencies beyond technical and pedagogical expertise. Effective leaders must be prepared in community organizing, political navigation, and equity-centered design. These capacities are

increasingly recognized as central to educational transformation [5], [31]. Leadership preparation in engineering education must therefore expand to include awareness of local industry networks, coalition-building, governance, and institutional analysis, equipping leaders not only to design programs but also to sustain systems.

Conclusions: From Pilot Programs to Public Infrastructure

Finally, this case cautions against continued reliance on isolated pilot programs and short-term grants. Hill's most durable impact emerged when programs were embedded within public systems through sustained coalitions among communities, school districts, universities, industrial partners, and funders. Research on STEM persistence consistently highlights the importance of institutional continuity and coordinated support structures [34], [33]. Policymakers and institutional leaders must therefore shift from episodic innovation toward sustained investment in integrated, longitudinal systems.

At the same time, the lessons from this case are not only instructive but also increasingly supported by a growing body of longitudinal and intervention-based research. Studies of university–school partnerships and early STEM career exploration demonstrate that sustained, community-engaged approaches can significantly strengthen student motivation, identity development, and participation in advanced academic pathways over time [36], [37], [23]. These findings reinforce that the model is not only conceptually sound but also empirically grounded and adaptable when implemented with fidelity to local context.

This moment presents a clear opportunity. New learning models are emerging that emphasize skill development and flexibility. They also prioritize partnerships across K–12 systems, higher education, and industry, especially in the context of artificial intelligence. These trends are increasingly aligned with the principles demonstrated in this case. The field now has both the evidence and the examples needed to move forward with intention. Universities and colleges, in partnership with their surrounding communities, are well-positioned to act on this evidence by adopting and scaling this model of learning. This approach supports STEM students through coherent, sustained pathways that strengthen career preparation and broaden participation in engineering. In doing so, institutions move beyond access alone toward intentionally designed systems that recognize the potential of all students, across both large, urban-centered and rural settings. These systems can cultivate a sense of belonging and sustain excellence across generations.

Taken together, these implications reinforce a central conclusion: success in engineering education is achieved through the intentional redesign of learning environments, leadership practices, and institutional structures to support all students.

Hill's life-course work demonstrates that when brilliance is assumed, opportunity is engineered, families are positioned as partners, and identities are cultivated early and continuously, engineering education becomes not a gatekeeping system but a generative one, capable of sustaining excellence and equity across generations.

Hill never speaks of "closing gaps." He speaks of opening doors.
"Our children are brilliant and can handle this."

The question his legacy leaves before us is no longer whether students can succeed, but whether institutions will act with the urgency and intention required to design systems worthy of their brilliance.

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