Proposal login | Tracks and Session Types | Instructions

Track. Research

Session Type. Research Report

Title. The Accessible Calculus: Black Engineering Students Pursue an Earned Insurgency

Abstract. The Accessible Calculus Project (ACP) is a collaboration with the National Society of Black Engineers (NSBE); Algebra Project (AP); NSBE students at Kennesaw State, Fairleigh Dickinson, and Harvard Universities; and Algebra 2 teachers to disrupt institutionalized barriers to success in Calculus. NSBE students and teachers are learning an approach to differentiation and integration that does not rely on Analysis, then incorporating AP's pedagogical and organizing principles to create curriculum for use in Algebra 2, informal learning settings, and a for-credit college precalculus class. This session reports the NSBE student-led efforts to prepare for and teach Precalculus.

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Descriptors.

Grade Band: 10–12; Higher Education

Subject: Students

Content and Categorical Domains: Access, equity, and empowerment; Calculus or higher-level mathematics

Methodology: Qualitative

Session proposal. (begins next page)

The Sputnik-era rhetoric of the need for well-prepared scientists persists to this day, traced through *A Nation at Risk* in 1983 as well as NSF's *STEM Education for the Future* in 2020. These messages tell us there are too few students taking advanced courses in mathematics [1], too few teachers well-prepared to teach rigorous and advanced mathematics courses [2,3], and too few schools offering challenging mathematics programs [4,5]. So, why might a message that "STEM can save us" [6] be prevalent and persistent, especially in English-speaking countries [7] and the "STEM deserts" of urban contexts [8]? Critical perspectives acknowledge that these messages often serve economic interests [9,10], privilege [11,12], or whiteness [6,13,22].

Yet, in a practical sense, mathematics has a stranglehold on access to both educational and economic opportunity [14,15,16,17], in which performance not only limits access to selective colleges and sought-after majors but negatively impacts issues of identity and agency [18,19]. Pre-COVID data provides an example of the effect on communities of Color [20]; mathematics achievement levels identify 32% of white 12th graders at or above proficient, yet Blacks performed at 8%, Hispanics at 11%, and Native Americans at 9%. These disparities are a product of systemic racism—a consequence of institutional constraints which perpetuate historical inequalities—and not simply an attribute of the students from the communities involved. Arguing that mathematics is a civil right, Moses and Cobb [16] make the link to race and racism clear:

> Math illiteracy is not unique to Blacks the way the denial of the right to vote in Mississippi was. But it affects Blacks and other minorities much, much more intensely, making them the designated serfs of the information age just as the people that we worked with in the 1960s on the plantations were Mississippi's serfs then. There is an urgency to this. (p.11)

If it is that outcomes such as mathematics achievement scores, inequitable enrollment in STEM majors, or participation in STEM fields are the product of systemic racism, might there be an institutional configuration which can ameliorate or even remove this condition? With the Accessible Calculus Project (ACP), we explore this possibility.

The National Society of Black Engineer's (NSBE) ambitious goal to graduate 10,000 Black engineers annually by 2025, structural obstacles of systemic racism must be removed along the educational pipeline. For Black engineers, these obstacles create barriers of awareness, access, and agency. The ACP addresses all three, first by approaching Calculus differently, and second by drawing upon the robust pedagogical and organizing principles of the Algebra Project.

The Root of Systemic Racism in Mathematics Education. The institution of Mathematics, and in service Mathematics Education, operates to perpetuate exclusion and privilege for its own prolongation as a white, patriarchal, cis-hetero, ableist, capitalist, colonizing structure of oppression [22,23,24,25].

> Mathematics Education operates as a mechanism for sorting bodies and producing dis/abilities, serving a neoliberal system that succeeds only when some humans are deemed deficit. The ahistorical and idealistic image of mathematics is used to dehumanize and punish, to create tragedies of failure and exclusion. [26, p.69]

Rather than recapitulate the persistence of inequitable academic, economic, and social outcomes of mathematics and school mathematics, we argue mathematics perpetuates systemic racism in that mathematics itself operating as whiteness, contributing to an

economic caste system, deficit orientations to learners, and the production of racialized mathematics identities [28]. Martin [29, p.323] names mathematics education as a *white institutional space*, characterized by four elements:

> (a) numerical domination by Whites and the exclusion of people of color from positions of power in institutional contexts, (b) the development of a White frame that organizes the logic of the institution or discipline, (c) the historical construction of curricular models based upon the thinking of White elites, and (d) the assertion of knowledge production as neutral and impartial, unconnected to power relations.

Calculus as the Barrier. Our project confronts (b) and (c) in a unique, and potentially productive way. Although all school mathematical topics had their origins outside Europe [30], as taught today, those mathematical ideas have been filtered through the logics of the white, male, European dominant world culture of the past 500 years [31,32]—a logic of hierarchy, domination, and exclusion [33,34]. The rigid deductive approach attributed to Euclid [32], heightened by the Bourbaki project, rejected intuition as a pathway to knowing (or as knowing). Instead, mathematical proof is to not rely on the creativity of intelligence, but instead be a logically derived, axiomatic process that can be mechanically checked [31].

The negative consequences of this precise, axiomatic approach to mathematical learning includes the belief that not all people do mathematics; favoring speed and accuracy over comprehension; and that there is no place for creativity and imagination in mathematics. We see this in the modern approach taken to the instruction of Calculus. While *change* (differentiation) and *accumulation* (integration) are commonly agreed to be the central topics of calculus, the approach is to unnecessarily invoke the machinery of Real Analysis—the limit—in order to teach these fundamentally algebraic and geometric concepts, concepts accessible in Algebra II. We argue this unnecessarily rigid, and conceptually advanced approach to foundational ideas of Calculus creates an unnecessary barrier. Yet it is one that persists in the logics of hierarchy, where under the spell of whiteness it is assumed that not everyone can do calculus and racialized outcomes are normal. This unnecessary approach to Calculus impacts achievement, identity, and progress toward dismantling systemic racism in STEM education.

The *Polynomial Calculus* curriculum draws only upon the mathematics of high school algebra and geometry to determine instantaneous rate of change and area under a curve [49,50,52,53,54]. Built into the curricular design is The Algebra Project's (AP) 40-year history of working directly with underrepresented and underserved students, a well-developed pedagogy, classroom structures, and professional development practices shown to positively impact student learning, agency, and persistence [cf. 47]. Our pedagogical model incorporates students' peer culture, from both inside and outside the classroom, to engage students in challenging, experiential learning [61], akin to Culturally Responsive Teaching [62]. The process bridges prior knowledge of events, experiences, and understanding with the world of mathematical language and sense-making, allowing students to be the creators of their own mathematical understanding [63]. For this project, we specifically utilize two core elements for instruction: the Five-Step Curricular Process [63] and the near-peer model [64].

Algebra Project Expertise in Responding to System Racism through Organizing. Based in Cambridge, MA, the Algebra Project (AP) works in an organizing mode to

identify resources to address the problem of systemic racism in mathematics, drawing on lessons from the organizing tradition of Mrs. Ella J. Baker and the Mississippi Theater of the 1960s Civil Rights Movement [43]. AP collaborates with schools, universities, and researchers to provide secondary mathematics education curricular interventions, pedagogical strategies, teacher development, and supports the development of local alliances with schools, to enable historically marginalized target students to gain the mathematical knowledge and practices necessary to: graduate high school on time, succeed in college and career, and participate fully as informed citizens in our highly technical, global society. Acquiring mathematics literacy is essential to family- and community-supporting workforce participation in the 21st century [16].

Three aspects of the community organizing traditions Moses learned from Baker in the Mississippi Delta in the early 1960s underlie AP work [16]: (1) the centrality of families to the work of organizing; (2) the empowerment of grassroots people and their recruitment for leadership; and (3) the principle of organizing in the context in which one lives and works—"cast down your bucket where you are." In Mississippi, sharecroppers came together in the fields for meetings about their concerns. They spoke in small groups, then one member reported to everyone gathered. The sharecroppers not only learned they had voice, but developed an agency bolstered by communal support. This same role of voice is critical to the AP classroom, rekindling the voice of young people disenfranchised by school mathematics. This voice comes with a confidence in understanding mathematics—something previously thought to be created and owned by others. This *others* view, as explored in Delpit's [44], "Multiplication is for White People," robs individuals of the type of agency that would allow them to approach mathematics creatively and constructively as one might do if it was viewed simply as a tool of a type of regimented language [45], that anyone can claim as their own.

To address this, critical AP pedagogical principles are designed to help students and teachers see the inherent and self-affirming power in both their collective and their individual voices. This is done through the Five-Step Curricular Process and by developing a discourse-rich classroom, where student-led whole-class and small-group discussions occur frequently, as with the sharecroppers. Because mathematics is often viewed as a set of pre-packaged concepts that are not to be questioned, discussions in AP classroom are used to unpackage it and allow the students to find their voice while they question and explore its fundamental claims and assertions. Aligned with the ACLU's [46] four-pillared approach to *Systemic Equality* to address America's legacy of racism and systemic discrimination, AP's pedagogical approach: (1) reconciles the past, (2) extends empowerment, (3) builds prosperity, and (4) increases access.

Grassroots organizing has successfully "fought" systemic racism in both the Mississippi Delta and in many AP classrooms [47]. Those most impacted are best positioned to understand the problem, define, and enact solutions. In contrast to many research programs originating in the university, where scholars design interventions they hypothesize will yield outcomes named in advance, the organizing design of this project requires the research team to immerse themselves in the lives of the community, "learning its strengths, resources, concerns, and ways of conducting business" [43, p.439]. Our researcher-as-organizer has taken an "evolutionary" view of our role in participating in the construction of the solution, one not known in advance, a methodological approach aligned with Youth Participatory Action Research [44].

The Accessible Calculus Project (ACP). ACP is a three year collaboration with NSBE students at Kennesaw State (KSU), Fairleigh Dickinson, and Harvard Universities, along with Algebra 2 teachers at high school near each site. Project goals include: (1) Refine the Polynomial Calculus curriculum, demonstrating the current approach to teaching Calculus unnecessarily serves as a gatekeeper to STEM careers; (2) empower future engineers to develop voice, agency and identity as practitioners and teachers of mathematics, and to place demands on educational systems that exclude their peers, an earned insurgency, and (3) empower Algebra 2 teachers through a deeper understanding of mathematics, culturally relevant pedagogies, and engaging curricular design to become leaders for their expertise in overcoming barriers to STEM.

During Spring 2024, the ACP built upon existing networks in each of the three sites to increase knowledge about the racialized functioning of STEM Education, and draw upon that interest to design a plan for action. Specifically at KSU, the project team met with the student members of the Kennesaw Society of Black Engineers (KSBE), in which a three-pronged approach emerged: (1) to collaborate with math teachers at a local high school to teach Algebra 2 in a way that introduced students to calculus and built a positive mathematics identity; (2) to build a Summer bridge program for incoming freshman, including a credit-earning Precalculus course; and (3) design curricular resources for the informal learning environments of NSBE Junior programs.

The work on item two during spring included weekly two-hour meetings of 12 KSBE youth with Dr. Lawler. The team examined the Polynomial Calculus curriculum, the AP 5-Step Pedagogy, and the organizing histories of the civil rights and modern AP movements. Further, we studied the university's precalculus curriculum and designed an eight-week credit-bearing precalculus course, to be co-taught by four KSBE students and Dr. Lawler in Summer 2024.

Project Goals 2 and 3 aim to understand the development of an earned insurgency, Goal 2 targeting the KSBE students. Calculus content knowledge will be measured primarily with the Revised Calculus Concept Inventory [68,69]. A variety of qualitative measures will examine the development of voice, agency, and identity of the KSBE students in relation to their role in impacting the success of future Black engineers. Together, these measures will inform the development of what we are naming *Gillen's* [64] *Insurgency Framework*.

Attendee Engagement. With this presentation, we will provide a backdrop of the ACP, but focus on the organizing and instructional efforts of the KSBE youth in the precalculus course taught during Summer 2024. The presentation agenda will be:

[5 min.] Project overview: rationale; approach to the calculus; pedagogical approach
[2 min.] Organizing youth and teachers, who know the inequalities best
[3 min.] Results of KSBE instruction of the Summer 2024 Precalculus course
[3 min.] In person (or video), KSBE students
[1 min.] Audience reacts via Padlet, with results displayed
[4 min.] Audience has time to share reactions, wonderings, insights, with neighbors
[2 min.] Audience "bruning comments" – peer-reviewed, brief statements/reactions

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