

### RESEARCH REPORT | SPRING 2020

# "Education does not transform the world. Education changes people. People change the world." $\sim$ Paulo Freire

How we define success in mathematics across the middle grades<sup>1</sup> in the U.S. education system should reflect the value we think mathematics holds for students during this formative time and for their life outcomes. Did the student arrive at the same answer as the textbook? How fast did they complete the problem? These traditional measures of success do not speak to the deeper purpose and relevance of the discipline: What is mathematics for? What contribution does it make to a young person's life? And the all-consuming question: how will they use it?

Mathematics success rooted in the myriad ways in which young people are able to express themselves, draw on their prior experiences and cultural knowledge, and integrate who they are in and outside of school would demonstrate that we believe students are more than empty vessels in need of procedural and numerical information and strategies. This vision for success would create the opportunity for students to bring their whole selves to their mathematics classrooms and learning experiences, paving the way for deeper engagement and understanding.

In the K-12 education system more broadly, education leaders, philanthropists, and researchers are coalescing around a new vision of success for students that is grounded in recognizing and supporting students as "whole people." A focus on whole people means that young people's academic success cannot be disentangled from their identities, socialemotional wellbeing, and developmental trajectories. And yet, this push to re-define success for students has not been fully realized in education policy at the local, state, or national level. Success in American education continues to be driven by narrow, decontextualized, and standardized test-based metrics and outcomes.

Several initiatives have underscored that learning is only possible when consideration is given to young people's brain and life stage development, racial/ethnic identity development, and socialemotional development. Examples include:

- UChicago Consortium's Foundations for Young Adult Success developmental framework
- Aspen Institute's National Commission on Social, Emotional, and Academic Development
- Science of Learning and Development Alliance and Darling Hammond et al.'s recent work
- Chan Zuckerberg Initiative's Whole Child investment portfolio

These organizations and projects are leading the way for policymakers and practitioners to rethink the dynamic interplay between teaching and learning. They build upon the work of scholars like Gloria Ladson-Billings, Carol Lee, and others who have dreamed and acted upon more expansive visions of success for decades.

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<sup>1</sup>This summary focuses on students in grades 3 through 9, in alignment with the Bill & Melinda Gates Foundation Middle Years Math strategy.

In mathematics education, this more holistic definition of student success is critical, but perhaps more difficult to achieve due to how we understand the discipline. First, mathematics education plays a unique role as an academic and cultural gatekeeper. Historically and contemporarily, it is the field that is most aligned with our notion of intelligence, not only creating a hierarchy among academic disciplines, but suggesting that there is a hierarchy among individuals and demographic groups who are perceived as good at mathematics and those who are not. In this narrow view that conflates mathematics knowledge with intelligence, we ignore the many contextual factors that have shaped the experiences and outcomes of marginalized groups in mathematics education. One consequence of this gatekeeping function is that it often precludes students from accessing more engaging mathematics courses.

Second, as a society, we have come to believe that mathematics is a culturally neutral, values-free discipline, which has limited the creativity and depth with which we teach mathematics.<sup>2</sup> Conceptualizing mathematics as a set of numerical procedures that are either right or wrong, rather than a process that requires critical thinking and meaningmaking, precludes us from understanding the rich history of the subject across cultures and time. This belief in neutrality also limits our understanding of success in mathematics. While teachers regularly use a variety of assessments to understand their students' mathematics performance, including homework, classwork, participation, and formative and summative testing, as a system, we overly rely on a single metric, standardized test scores, and compare those scores across groups to understand success. While it may not be possible to use a more robust set of assessments at a system level, the lack of meaning-making between standardized tests scores such as NAEP scores and teacherdeveloped assessments leave us with decontextualized cross-group comparisons. In his critical analysis of the ways in which race, in particular, is understood in the study of mathematics, Danny Martin notes that differences in mathematics performance across race are understood by many in the field as "factual and indisputable" differences in mathematics aptitude.<sup>3</sup> This understanding belies a blind confidence in standardized test scores with little regard given to the individual and structural means by which race and racism affect Black and other marginalized students' experiences of mathematics.

Like many systems, education systems are perfectly designed to produce their outcomes. The U.S. education system produces and perpetuates stratified experiences, leaving students from the most marginalized communities with little opportunity to meet the system's standards of success.<sup>4</sup> In such a system, achievement gaps are virtually insurmountable and have become normalized. The use of standardized test scores to understand achievement in mathematics (and in academic outcomes generally) and the focus on closing gaps serves as a barrier to a more robust understanding of the issue at hand and demonstrates how narrowly we currently define success. Redesigning our education system to become one in which all students are supported and expected to succeed in mathematics requires examining our definition of success and the array of systems and actors that support it.

A useful thought exercise to expand our understanding of mathematics success might be to imagine how we each would define success for our 12-year-old selves, as focusing inward often allows one to have more empathy for others. Recall the young person who showed up to school every day (or didn't, because doing so was too overwhelming) full of adolescent insecurities about who you were and how other people perceived you. The you who was looking to be validated. The you who wanted so badly to just fit in. By taking a moment to consider ourselves and what our needs were as adolescents, we can begin to envision a definition of success that is expansive and compassionate, is relevant in and outside of school, and leverages the truly curious and creative nature of young people.

The next part of this thought exercise might ask us to sit with a bit of discomfort. Those of us with any and multiple forms of privilege should ask ourselves some deeper questions and consider whether all of us are situated to have our visions of success actualized. White friends, friends who hate hearing the term 'implicit bias,' friends from marginalized communities who struggle to negotiate the dynamics of being a part of and separate from marginalized student communities, friends who think they do not see color, the teacher in that elite public high school who rolled his eyes and breathed a sigh of disgust upon seeing the title of my presentation on student belonging, I am talking to you. Stay with me and allow some space for the discomfort you are feeling right now.

(Cont.)

<sup>&</sup>lt;sup>2</sup> Gholson, Maisie L. (2020). Big Mathematics: Centering the Humanities in Mathematics Learning and Identity Development. Working Paper.

<sup>&</sup>lt;sup>3</sup> Danny Bernard Martin (2009). Researching Race in Mathematics Education. Teachers College Record, 111(2), pp. 296.

<sup>&</sup>lt;sup>4</sup> Duncan, Greg J. and Murnane, Richard J. (Eds.) (2011). Whither Opportunity?: Rising Inequality, Schools, and Children's Life Chances. Russell Sage Foundation.

Try to imagine negotiating adolescence when your race/ethnicity, family's income, primary language, gender, sexual orientation, and citizenship status are used as determinants of your mathematics abilities or perceived as deficits to be overcome. Imagine not knowing what it is that prevents adults from building authentic relationships with you and from seeing the version of you who shows up to school as whole and excellent and who is a learner because of, not in spite of, your background. Imagine how it would feel for your vision of success for yourself or communicated to you by your family, community, and rich cultural history of perseverance, to be invalidated by the very adults meant to prepare you for your future. If you cannot imagine what this feels like, I am not here to suggest that you are a bad person or that you do not care. I am suggesting that we are all party to an education system that cannot envision, and actively resists envisioning, success for our most marginalized students in mathematics contexts.

## MAPPING RESEARCH INSIGHTS ONTO THE BUILDING EQUITABLE LEARNING ENVIRONMENTS (BELE) FRAMEWORK

In 2019-20, the Mindset Scholars Network Inclusive Mathematics Environments (IME) Early Career Fellowship brought together a cohort of 10 early career scholars, two faculty contributors, and a network of senior scholars who served as mentors to study inclusive mathematics environments for students in grades 3-9. The IME fellowship was designed to bridge multiple academic disciplines, including mathematics education, psychology, and sociology, in order to advance our knowledge of inclusive mathematics environments for students with stigmatized identities in mathematics, including Black, Latinx, and Native American students; students from families facing economic disadvantage; students who are designated English language learners; and girls. The IME fellows and faculty contributors proposed a range of questions and topics to explore what is known from research about inclusive mathematics environments from diverse, but interrelated perspectives (Table, Page 4). In their research insights, they each delineate how marginalized and minoritized students currently experience mathematics environments and describe opportunities to create mathematics contexts that are more inclusive. Their insights help us better understand the contexts and interactions in which marginalization, and thus exclusion, take place and help to identify ways to make mathematics learning environments more inclusive.

This interpretive summary was included as part of the fellowship to summarize the research insights articulated by the IME fellows and faculty contributors in the context of education practice and policy. To achieve a more holistic definition of mathematics success that includes all students, educators and education leaders must ground their work within new ways of understanding what our system broadly, and mathematics environments specifically, need to look like. Thus, this interpretive summary relies on the Building Equitable Learning Environments (BELE) framework<sup>5</sup> as a

lens to consider how a system that centers the multitude of student experiences can actively dismantle marginalizing beliefs, actions, structures, and policies.

The BELE framework "envisions learning environments wherein every student emerges from their K-12 learning with *affirming, liberating, meaningful experiences*<sup>6</sup> that foster intellectual, social, emotional and cultural growth and wellness." In such a learning environment, student background characteristics (e.g., race, class, language, gender) that are used to marginalize and minoritize young people and their communities should have zero predictive power in educational experiences and outcomes. Further, the framework indicates that all of our adult activities at every level of the system should be truly student-centered, focusing on students' voices, outcomes, and experiences, particularly the experiences of the most marginalized students.



The BELE framework consists of four drivers (*Figure*) that are critically important in creating affirming, liberating, and meaningful student experiences and shaping student outcomes: the work of teaching and learning, the schoolwide systems and structures in place, the policy and advocacy that determines educational priorities, and partnerships with family and community. In each of the sections that follow, an

<sup>6</sup> Experiences that make students feel seen and valued, are designed to challenge oppression, and are relevant to students' lives.

<sup>&</sup>lt;sup>5</sup> The BELE Framework was developed from the learnings of the BELE Network, funded by the Raikes Foundation. The BELE Network (2016-20) brought together ten School Support Organizations (SSOs) from across the country to increase equitable experiences and opportunities for marginalized students in their school partnerships by grounding the SSOs' work in research on learning and development with an equitable lens and continuous improvement practices.

## IME FELLOWS' AND FACULTY CONTRIBUTORS' RESEARCH QUESTIONS

How do students, adults, institutions, & systems negotiate, resist, or actively disrupt epistemic bias influenced by genderism and sexism in mathematics? (Agarwal)

By what processes are students marginalized in K-20 mathematics classrooms? What do different theories of marginalization suggest about responding to and addressing marginalization in K-20 mathematics classrooms? What theories of marginalization may be missing and what are the implications for mathematics education research? (Chen & Horn)

How do different conceptions of mathematics (i.e., the ontology of mathematics or what mathematics is) create difference constraints and affordances for the development of a positive, robust mathematics identity? (Gholson)

What factors shape the effectiveness of role models in supporting the development of positive identity and psychological experiences in mathematics, particularly for students who have been minoritized in mathematics? (Gladstone & Cimpian)

How does the culture of STEM environments in college—through their norms and practices—facilitate or impede inclusion for various social groups based on social class, race/ethnicity, and gender? (Johnson)

Can teachers be trained to curb prejudice expression in mathematics classrooms? If so, how? What are the challenges specific to mathematics classrooms? What are potential solutions? (Kroeper & Murphy)

How has equity been theorized and explored in mathematics education across elementary, middle, secondary, and postsecondary levels? What are implications for studying and designing inclusive undergraduate mathematics environments? (Leyva, Balmer & McNeill)

What are the relationships among classroom opportunities, learning processes, and Black and Latinx identities in mathematics? (Miller-Cotto & Lewis)

What forms of capital do Black students possess that could be advantageous to the learning of mathematics? (Ortiz)

How might insights from work on social justice pedagogies and utility-value interventions be integrated to inform the next generation of relevance-focused curricular innovations and interventions to support inclusive teaching practices in middle school mathematics classrooms? (Priniski & Thoman)

What are the experiences of queer students in mathematics environments and what are the factors that help contribute to inclusive mathematics environments for queer students? (Voigt & Reinholz)

What features of mathematics environments nurture positive mathematical identities for Black learners? (Wilkes & Ball)

element of the BELE framework is described and the research insights of the IME fellows and faculty contributors are explained in light of the corresponding framework element. The final section of this summary suggests levers for equitable and inclusive systems change.

To reimagine success in mathematics education from the BELE perspective, there is a need to problematize the current culture of mathematics teaching and learning. That involves challenging the notion of mathematics as a values-free, culturally neutral subject and engaging in *critical consciousness* raising for educators and education leaders building awareness of and taking action against inequities. By doing so, we are positioned to change how mathematics is taught and experienced by students. Further, by interpreting the IME findings through the lens of the BELE framework we can identify new possibilities for defining, recognizing, and eliciting success in mathematics environments.

#### **Student Experience and Outcomes**

The experience of school as affirming - where students are able to grow academically, build a sense of agency, positively explore their identities, see connections to their cultures and racial histories, contributions, and knowledge, and make meaningful connections to others - should be the core work of schooling, according to the BELE framework. By rooting the IME fellows' research insights in that perspective, we can identify practices and structures that would lead to such affirmation for marginalized and minoritized students.

Chen's research insight creates a useful starting point for us to understand the complex process of marginalization and its impact on student experience.<sup>7</sup> According to her review of the literature, marginalization flows from tangible to more abstract actions and experiences. It can be individual, in that individual discriminatory practices can affect student experience, as well as material, in that access to resources has been systematically denied to some students. Marginalization is also *structural* in that school policies can contribute to the process of marginalization (e.g., minoritized students are less likely to test into advanced mathematics classes) as well as ideological in that educator beliefs can marginalize students (e.g., educators are more likely to have lower expectations for certain students). These forms of marginalization can be mutually reinforcing. For example, Chen writes, "Students excluded from opportunities to explore mathematical ideas

using their own language and resources (material) may then be seen as uncreative or incapable of tackling rich problems (ideological)."

The larger cohort of IME fellows helps us to name specific situations and practices that lead to inclusive or exclusive student experiences. In exploring teacher education strategies, Kroeper notes the emotionally, physiologically, and cognitively taxing nature of mathematics environments for marginalized students. When students must contend with the psychological threat of questioning whether they belong in a particular mathematics environment, are concerned with whether their peers or teacher believe they belong in that environment, and/or are experiencing bias, they are expending cognitive energy to manage these concerns, which depletes the cognitive energy they have to attend to their mathematics performance. As Kroeper states, many scholars recognize that marginalized students have to engage in emotional labor just to participate in mathematics.<sup>8</sup>

Miller-Cotto<sup>9</sup> and Gholson suggest that because of prejudice, the opportunities for marginalized and minoritized students to access mathematics identities become restricted. *Identity development* is the process by which young people come to understand who they are in the world based on their experiences and beliefs about themselves. Mathematics identity specifically relates to an individual's sense of being a "math person," or as Miller-Cotto explains, feeling empowered to engage in mathematics.

While students have agency in constructing their own identities, feedback and implicit messages from others can affect students' sense of self within a mathematics context. Wilkes exemplifies this through his discussion of student positioning, or how students are characterized as participants in classroom environments.<sup>10</sup> Positioning theory, he writes, "focuses on how interactions afford and constrain different identities that may be taken up, modified, or resisted [...] Learners position themselves, are positioned by their peers, and are positioned by their teachers during mathematics instruction." If this positioning is productive, meaning students are characterized as valued members of the class, then students build on that sentiment and have the potential to engage more in mathematics. However, if the positioning is problematic, marginalized students can potentially withdraw. These insights demonstrate the psychological toll taken on students when their status and value as members of the

<sup>&</sup>lt;sup>7</sup> Chen, Grace A. and Horn, Ilana S. (2020). Reviewing the Research on Marginalization in Mathematics Education. Working Paper. Please note that while this paper has two authors, it is credited to Chen in the text given her role as IME Fellow.

<sup>&</sup>lt;sup>8</sup> Kroeper, Kathryn M. and Murphy, Mary C. (2020). Toward Increasing Equity and Inclusion in Mathematics Classrooms: Exploring the Potential of Proactive Confrontation in Teacher-Education. Working Paper. Please note that while this paper has two authors, it is credited to Kroeper in the text given her role as IME Fellow.

<sup>&</sup>lt;sup>9</sup> Miller-Cotto, Dana and Lewis, Neil A. (2020). Am I a "Math Person"? How Classroom Cultures Shape Math Identity Among Black and Latinx Students. Working Paper. Please note that while this paper has two authors, it is credited to Miller-Cotto in the text given her role as IME Fellow.

<sup>&</sup>lt;sup>10</sup> Wilkes, Charles E. and Ball, Deborah L. (2020). Positioning, what do we know? An Investigation of Black Learners Positioning in Mathematics Classrooms and the Role of Intersectionality as an Analytical Tool for Understanding. Working Paper. Please note that while this paper has two authors, it is credited to Wilkes in the text given his role as IME Fellow.

classroom community are not clear. Classroom environments that are taxing, restrictive, and lead to withdrawal have the potential to prohibit students from fully engaging in the work and potentially preclude marginalized students from developing mathematics identities.

Another factor critical to student experience in mathematics classrooms is representation. The field tends to focus on race when highlighting the need for representation, and racial representation is still a persistent and critical need being unmet. In lifting up the experiences of students with minoritized sexual identities<sup>11</sup> in mathematics environments, Voigt pushes for a more robust approach to representation that encompasses identities that have the potential to be "invisible."12 Though there is a dearth of research exploring this topic, we know that there tends to be lower enrollment of students with minoritized sexual identities in mathematics courses as compared to other academic content area courses. Voigt also notes that mathematics environments can be cognitively stressful because they privilege heteronormative masculinity in direct and subtle ways. For example, solving certain mathematics word problems requires the assumption that gender is binary or that marriage only happens between a man and a woman, and it is commonly assumed that sexual identity is irrelevant to mathematics identity. Voigt suggests that seeing one's self mirrored in curriculum is an important facet of student experience. Introducing and expanding representation in curriculum and practice (e.g., using correct pronouns; challenging microaggressions) has the potential to affirm for students the wholeness of their being and experiences in and out of school and support educators in developing a more critically conscious lens in their work.

Without an understanding of how students use resistance and positioning to protect their sense of self, teachers and administrators can misinterpret this behavior as students being disinterested or off-task.

Marginalized students are not without agency in experiencing mathematics environments. As students assess and respond to the environmental factors that drive marginalization, positioning and resistance can be a means by which they challenge the dominant culture. As Wilkes notes, marginalized students can position themselves by engaging in the class or not, and Ortiz<sup>13</sup> and Agarwal<sup>14</sup> both provide ample evidence of student resistance as a means of asserting one's self in the mathematics environments through subverting the norms of participation or leveraging other forms of participation (e.g., peer support and collaboration). Without an understanding of how students use resistance and positioning to protect their sense of self, teachers and administrators can misinterpret this behavior as students being disinterested or off-task. Agarwal reviews qualitative research demonstrating the differing experiences between two students in advanced courses, one whose cultural experiences were consistent with the dominant, meritocratic culture and one whose cultural experiences were not. Through interviews, the researcher noticed that the latter student, an African American student, began to change her behavior, by changing how she spoke after being called "loud" and not hanging around friends who weren't considered "advanced," as a result of her teacher's deficit-based interactions with her. These behaviors demonstrate that the student had to change her identity to assimilate in her mathematics classroom, rather than having the opportunity to develop a cohesive mathematics identity.

Johnson notes that students attending under-resourced schools are often educated in a compliance fashion that does not surface cultural ways of knowing, or the ways in which young people understand mathematical concepts outside of school and in their home cultures.<sup>15</sup> In this way, traditional procedural approaches to mathematics cause educators to miss opportunities to make connections with marginalized students and their experiences of mathematics. Priniski makes a similar point in her review that brings together two distinct bodies of research on utility-value and teaching and learning mathematics for social justice.<sup>16</sup> She concludes: "An inclusively relevant math learning environment needs to be for all students in the sense that (a) it is not against them (i.e., not exclusionary, not perpetuating stereotypes about math ability), (b) it is designed with them in mind (i.e., resonates with their lived experiences, cultural values, and background), and (c) it invites them to co-create math instruction that is meaningful for them (bringing each individual student into the process)." Without access to culturally-responsive and relevant education and variety in opportunities for skill development in the middle grades, students may not be adequately prepared to transition to higher level mathematics courses.

- <sup>13</sup> Ortiz, Nickolaus A. (2020). (Ontologically) Black and Proud. Working Paper.
- 14 Agarwal, Priyanka (2020). Disrupting Gendered Epistemic Injustice in K-12 mathematics A Research Synthesis. Working Paper.
- <sup>15</sup> Johnson, Anthony (2020). Untitled Working Paper.

<sup>&</sup>lt;sup>11</sup> Voigt defines students with minoritized sexual identities as students who identify as lesbian, gay, bisexual, transgender, two-spirit, intersex, pansexual or in other ways queer because of their sexual identity or non-cisgendered identity.

<sup>&</sup>lt;sup>12</sup> Voigt, Matthew and Reinholz, Daniel L. (2020). Calculating Queer Acceptance and Visibility: A Literature Synthesis on Queer Identity in Mathematics. Working Paper. Please note that while this paper has two authors, it is credited to Voigt in the text given his role as IME fellow.

<sup>&</sup>lt;sup>16</sup> Priniski, Stacy J. and Thoman, Dustin B. (2020). Fostering an Inclusively Relevant Mathematics Environment: The Case for Combining Social-Justice and Utility-Value Approaches. Working Paper. Please note that while this paper has two authors, it is credited to Priniski in the text given her role as IME Fellow.

As several of the fellows and faculty contributors (Gholson, Ortiz, Agarwal, and Miller-Cotto) indicate, centering marginalized students' identities and cultural experiences in mathematics environments and assessments can reframe students' experience in ways that validate the richness of their backgrounds and allow them to experience mathematics without compromising who they are.

#### **Teaching and Learning**

Educators are at the heart of teaching and learning and are a primary driver of student success. In the BELE framework, in order to prioritize student experience, educators must become critically conscious of and curious about the norms of participation and criteria (both behaviorally and academically) for success they are foregrounding for students. This means educators must ground their instructional expertise in culturally responsive and engaging pedagogy that is representative and relevant to the students in front of them while also making connections to the broader world, create classroom communities that normalize productive struggle and lead students in developmental experiences, and actively challenge and create healing spaces to repair the harm done by systemic oppression. Educators also need and should model growth mindsets - demonstrating that intelligence is not innate, but the result of working through challenges - as well as engage in collaborative practices and feedback loops with their adult peers.

In concrete terms, the research insights explore two means by which marginalization takes place in the interactions between teachers and students: what teachers believe about students (generally, and specifically with regard to their mathematics abilities) and what teachers do (or do not do) with students. In his exploration of positioning, Wilkes notes how teachers' identities and their beliefs about Black learners can influence their discretion during classroom instruction; for example, when a teacher asks a student to explain a concept they have mastered to the rest of class, they position that student as smart and capable, but bias can make teachers less likely to choose Black students for that role. In order to create equitable and inclusive mathematics environments, teachers can engage in active reflection around how their biases affect student participation in mathematics. In a study that found teacher biases in students' mathematical abilities (even within like groups, such as the perceptions of teachers of color about students of color and the perceptions of female teachers about girls' abilities), the authors suggest professional development interventions that bring awareness to implicit bias as well as those that ask teachers to reflect on their

beliefs about what student participation should look like.<sup>17</sup>

Miller-Cotto, Chen, and Leyva<sup>18</sup> all identify specific ways teachers can shift their practice to interact with students differently. Miller-Cotto notes that educators' mathematics instructional practices often convey messages to students about who is and who is not a "math person" through praise of certain groups of students (typically white or male) or the lack of affirming interactions with students with marginalized identities. She describes concrete pedagogical moves such as dialogic instruction, in which students are engaging in mathematics content and in interpersonal interactions in participation, to build a more active and agentic culture of participation in mathematics environments. She also calls on the work of Boaler and others to push teachers to humanize the learning of mathematics by situating learning in real life examples. For instance, in Boaler's comparative case study of two schools' approaches to mathematics instruction, she found that when she asked students in the more traditional school what they were working on, the students would typically reference the chapter and type of exercise. However, in the more progressive school, this question elicited an answer that demonstrated where students were in understanding the problem they were working on, their findings, and hypotheses about what they might find out as they continued their projects.<sup>19</sup>

Educators' mathematics instructional practices often convey messages to students about who is and who is not a "math person" through praise of certain groups of students (typically white or male) or the lack of affirming interactions with students with marginalized identities.

Levva suggests that educators can challenge traditional exclusionary mathematics norms (e.g., speed) and beliefs (e.g., innate mathematical ability), asking educators to rethink how they structure classroom participation and norms. Chen highlights *equitable noticing*, in which explicit positive and affirming attention is bestowed upon marginalized and minoritized students, as well as the importance of paying attention to relationships and developing positive interactions with marginalized students. When educators understand that, like the relationships in their personal lives, relationships with students must begin with self-awareness and must be sustained with open and curious communication, they can structure more equitable and meaningful learning environments.

<sup>17</sup> Copur-Gencturk, Yasemin et al. (2019). Teachers' Bias Against the Mathematical Ability of Female, Black, and Hispanic Students, Educational Researcher.

<sup>&</sup>lt;sup>18</sup> Leyva, Luis A., Balmer, B. and McNeill, Taylor (2020). Toward Equity-Minded Research in Undergraduate Mathematics Education: A Review of Equity Research across Mathematics Education and Higher Education. Working Paper. Please note that while this paper has three authors, it is credited to Leyva in the text given his role as IME faculty contributor.

<sup>&</sup>lt;sup>19</sup> Boaler, J. (1998). Alternative approaches to teaching, learning and assessing mathematics. Evaluation and Program Planning, 21(2), pp. 129–141.

#### **Schoolwide Systems and Structures**

The BELE framework calls for schoolwide efforts that focus on increasing educator professional agency in service of students. In this aspiration, schools have structures that allow educators to engage in collaborative inquiry and peer observation and coaching. In these environments, innovation is supported and expected; professional development and instruction are student-centered; the policies, practices, and cultural representations that comprise the school are equitable; and adults are intentionally thinking about the distribution of their social capital - their access to information and networks - in service of students, particularly, the most marginalized students.

Shifts in professional development can help teachers to reflect more on their own identities and backgrounds as well as teach them how to help students navigate the hidden curriculum, or the norms of participation that are unspoken.

Several of the fellows and faculty contributors note the structural barriers that result in exclusionary rather than inclusive mathematics environments, namely, professional development approaches, curriculum, assessment, and tracking.

Professional development should challenge educators to grapple with their bias, shift their beliefs about mathematics learning and marginalized students' abilities, and understand student identity as a means to more fully engage students. Leyva, Agarwal, and Kroeper each argue for shifts in professional development that start in teacher education programs. Kroeper proposes that teacher education programs can use a proactive confrontation approach in supporting future teachers to navigate how bias will appear in their work with students. Proactive confrontations include raising individuals' awareness by demonstrating how actions might be biased toward marginalized students and how they can intentionally plan to engage differently with students. Agarwal explores self-study, or engaging teachers by having them reflect on their experiences with and belief systems that lead to biases against marginalized students, as one potential professional development approach to addressing bias. Leyva in particular calls for a reframe of mathematics that is equity-oriented, arguing that teachers need access to political knowledge to navigate unjust schools and policies, meaning that they understand the context in which they are teaching in a way that reaches beyond mathematics content and encompasses how educational structures are

affecting their students. Armed with political knowledge, teachers can challenge deficit notions about marginalized students and organize their teaching in ways that humanize mathematics environments. At an individual level, these shifts in professional development can help teachers to reflect more on their own identities and backgrounds as well as teach them how to help students navigate the hidden curriculum, or the norms of participation that are unspoken.

Others call for innovations in curricula and use of textbook alternatives to center marginalized and minoritized student identities in mathematics teaching and learning. While this can create an additional burden on educators when enacted at the classroom level, existing resources can expand representation in the curriculum and support students' conceptual rather than procedural understanding of mathematics (for instance, the Algebra Project's focus on mathematics literacy might serve as a model alternative curriculum). Gladstone notes that using role models both in the curriculum and beyond (e.g., inviting a guest speaker from the community into class) is another important way mathematics teachers can create more inclusive mathematics environments.<sup>20</sup>

Assessments based on group work have the potential to tap into the genius of young people whose communities and cultures function from a collectivist perspective rather than an individualist perspective.

Additionally, using multiple forms of assessment at the school and classroom levels can more accurately capture learning and skills acquired by all students. Ortiz notes that assessments based on group work, for instance, have the potential to tap into the genius of young people whose communities and cultures function from a collectivist perspective rather than an individualist perspective.

Tracked courses, in which some measure of mathematics achievement is used to assign students to separate classes, can also contribute to the marginalization of students. Jeannie Oakes' seminal text, *Keeping Track*, suggests that tracking contributes more to segregation than increased achievement, with students in lower track classes receiving fewer opportunities for rich and engaging coursework; as she notes in her concluding chapter, *The Search for Equity*, "High-track students got mathematical concepts; low-track students got computational exercises. Why?".<sup>21</sup> In far too many schools, assumptions about student ability are based on biases about students' demographic backgrounds. Chen cites

<sup>&</sup>lt;sup>20</sup> Gladstone, Jessica R. and Cimpian, Andrei (2020). Role Models Can Help Make the Mathematics Classroom More Inclusive. Working Paper. Please note that while this paper has two authors, it is credited to Gladstone in the text given her role as IME Fellow.

<sup>&</sup>lt;sup>21</sup> Oakes, Jeannie; Goodlad, John I.; and Kerr, Austin K. (1985). Keeping Track: How Schools Structure Inequality. Yale University Press.

literature suggesting that students of color and low-income students are often tracked out of mathematics courses that are considered college preparatory. While on the surface, professional development approaches that give educators new equity-centered approaches to working with students (as Leyva's work notes above) could serve as a shift in structures, a more radical approach to consider in conjunction with equity-centered professional development would be detracking mathematics courses all together. As suggested by fellows and faculty contributors, detracking can be paired with professional development for teachers that focuses on equitable outcomes, innovative approaches, teacher-peer support.

#### **Family and Community Partnerships**

When families and communities have access and influence within schools, students experience consistency in their home lives and school lives. Accordingly, the BELE framework calls for schools to foster trust among families and create opportunities for family and community involvement. School governance and decision-making structures should be transparent and accessible to families and communities. Finally, relationships between schools and families should be supportive and grounded in partnership.

The work of Ortiz and Agarwal uncovers how resistance serves as a form of self-preservation in school settings for many marginalized students. In the face of school structures that position students' communities and ways of interacting in the world as inferior, acts of resistance like acting like they do not care about the work or disrupting class can be a student's way of protecting their sense of self. Both authors suggest ways in which schools can engage with and learn more about the cultures and community wealth of their students, including engaging students' cultural identities in learning.

Co-constructing knowledge can help students see their community lives reflected in the classroom space. In turn, co-construction can mitigate students' sense that they have to shed who they are in order to be accepted in school.

By understanding what purpose resistance serves for students and building on it as an asset of students and framing mathematics environments as sites of co-construction of knowledge, schools can become more inclusive places for students, as well as their families and communities. Co-constructing knowledge can help students see their community lives reflected in the classroom space. In turn, coconstruction can mitigate students' sense that they have to shed who they are in order to be accepted in school. Further, schools can look for opportunities to innovatively engage students' community knowledge through curricular choices that are relevant to the experiences of students' families and communities. Priniski notes one such example from the book Rethinking Mathematics in which the teacher and students explored wages as an introduction to linear equations.<sup>22</sup> Students discussed the minimum wage vs. a living wage, researched and graphed typical wages in their communities, and then added in other factors such as expenses to both learn about issues within their communities and complicated mathematical concepts. Schools can also engage students' communities as role models for mathematics identities (e.g., small business owners) as well as work with caregivers to shift the narrative about mathematics from one that is decontextualized from the lives of students to mathematics being everywhere in their lives.

#### **Policy and Advocacy**

The BELE framework calls for education leaders who actively assess and work to dismantle discriminatory structures and policies at the district, state, and federal level. These leaders use a *targeted universalist* approach by recognizing that different groups are situated differently in society and that marginalized students tend to be situated the furthest from opportunity. With this recognition, education leaders can develop universal goals for all students with differing pathways for subgroups of students to achieve said goals.

An example of a policy effort to center student experience is Seattle Public Schools' plan to create a mathematics curriculum that engages students' lived and community experiences. Still under debate, the proposal for an ethnic studies-based mathematics curriculum focuses on cultural experiences of mathematics (i.e., how mathematics has been used historically in acts of resistance or how mathematics has been used to oppress different groups). While an important step, a shift in curriculum will necessitate a shift in the teacher training and professional development opportunities available to teachers. Another potential policy move is to de-track mathematics classes given that tracking mostly serves to segregate students.

## SHIFTING THE DISCIPLINE IN SERVICE OF EQUITY AND INCLUSION

Articulating the challenges to building inclusive mathematics environments within the parameters of the Building Equitable Learning Environments framework sheds light on the current state of the educational ecosystem, which does little to benefit the most marginalized and minoritized students in our schools. In each element of the framework, the IME

<sup>22</sup> Dean, Jana. (2013). Living algebra, living wage. In E. Gutstein & Peterson, B. Rethinking mathematics: Teaching social justice by the numbers (2nd ed., pp. 67-77). Rethinking Schools, Ltd.

fellows' research insights explore the relational interactions, structures, and policies that lead to inequitable student experiences and outcomes within mathematics environments.

Faculty contributor Gholson also suggests that the discipline itself is in need of reimagining. Mathematics is taught as a discipline in which the technical aspects of the work are the only means of making sense of and understanding mathematics. Such a framing decontextualizes mathematics from the lived experiences of people. Gholson's anecdote that the table of contents of most mathematics textbooks focuses solely on procedures confirms this. She argues that mathematics cannot be disconnected from social context; it must "begin with the human connection." Her point may be too easily interpreted as making mathematics education relevant to the real world; if we just have more personal finance courses for high school students, for instance, we will solve the seemingly intractable problem of mathematics not being useful outside of school.

While a use-case for mathematics is important, Gholson's point is that mathematics influences our societal decision-making and is a part of daily life, historically and contemporarily, and as such it is not solely a cognitive exercise. The Seattle Public Schools proposal for an ethnic studies-focused mathematics curriculum mentioned above would ask students to consider how mathematics has been used in economics movements over time and to use mathematics and data to understand shifting high school graduation rates over time. Mathematics can and should hold purpose for learners and purpose comes to life through the stories we tell and in our ways of being.

Gholson provides a compelling example of the history of negative numbers. The concept of negative numbers is something that many elementary age students struggle to comprehend as teachers primarily focus on explaining the "laws of signs" to students. However, there exists a rich history of mathematicians debating the value of and grappling with the use of negative numbers. From 7<sup>th</sup> century Indian mathematicians considering negative numbers to be a debt (or subtraction) in attempting to solve mathematical operations to 16<sup>th</sup> century European mathematicians considering negative numbers to be "absurdities" (or not useful) and finally becoming a part of common mathematical practice in the 19<sup>th</sup> century, the history of negative numbers demonstrates that mathematics is constructed by people and cultures rather than existing solely as a set of procedures. The concept of negative numbers has an important storyline throughout history that has shifted as societal understanding

of the value and use of negative numbers has shifted.

In my own work, I interviewed an adolescent boy who reflected on his "best teacher" being an 8<sup>th</sup> grade mathematics teacher who taught the class not just the procedures of mathematics, but also provided historical context.<sup>23</sup> He told the stories of how certain algorithms were developed, making mathematics instruction compelling and memorable. In Gholson's framing, one could argue that the vast majority of mathematics learners are receiving inadequate mathematics instruction that does not connect with them on a human level; students, marginalized or not, are not consistently receiving compelling and memorable mathematics instruction. And yet her framing is rightly rooted in justice.

Positioning mathematics as culturally neutral and values-free not only frames it as ahistorical and without context, but also devalues the wealth of mathematical knowledge found in marginalized and minoritized communities and histories.

Other disciplines (e.g., social studies) also foreground white, cisheteronormative experiences, but are contested spaces where we debate, as a society, which stories get told. Positioning mathematics as culturally neutral and values-free not only frames it as ahistorical and without context, but also devalues the wealth of mathematical knowledge found in marginalized and minoritized communities and histories.

The understanding, narrative, and norms of mathematics environments and the discipline can be changed. Schools and classrooms are social contexts in which the construction of mathematics can be reproduced or disrupted.

## Identifying Levers to Build Equitable and Inclusive Mathematics Environmetns

Research insights surfaced by the IME fellows, faculty contributors, and the broader field point to levers that can be used to create new interactions and experiences for students; each lever works on its own and in conjunction with the others to build momentum for the construction of more equitable learning environments. However, these levers do not exist in a vacuum. Without an examination of the ways in which current policies are grounded in structural racism and negatively affect marginalized and minoritized students, any lever for change is simply a technical solution that will

<sup>23</sup> Not yet published.

result in few, if any, benefits for the students for whom we most wish to create new experiences. The levers also are deeply intertwined. Changes in one area will necessarily call for changes in another. As with any social policy, education leaders must grapple with the inherent complexity and messiness of change work.

#### Assessment

Changing assessment strategies is perhaps one of the most needed shifts we can make in the field and perhaps is one of the most vexing. Much of the American K-12 education system is entrenched in a reliance on standardized test-based accountability systems. Teachers in search of more nuanced and responsive ways of assessing student learning are likely to face barriers when it comes time to translate more meaningful assessments into the grading structures in place within their districts.

Discussing mathematics assessment at an event hosted by the Mindset Scholars Network,<sup>24</sup> Na'ilah Suad Nasir, president of the Spencer Foundation and co-author of *Mathematics for Equity: A Framework for Successful Practice*,<sup>25</sup> stated: "We don't assess learning in the ways that allow us to understand the things that we care about most. We assess learning in ways that allow us to know the thing that we can know, but it's not the thing we want to know or need to know." Knowing the things we can know (as determined by standardized tests) only answers a limited and limiting set of questions about student learning and engagement. This may be especially true in mathematics where it is all too easy to rely on the neutrality of numbers.

A more robust check for mathematics learning would involve more than just solving equations. In Mathematics for Equity (of which Dr. Nasir is also an editor and author), the authors identified that an important concept within mathematics pedagogy was the idea of "multidimensionality." Multidimensionality acknowledges that there are many ways to understand content and approach problems; therefore assessments must account for students' multiple ways of knowing as well as the individual and collective roles students possess in mathematics learning by understanding how students support one another in their learning. Nasir and her co-panelists at the Mindset Scholars Network event also put forward a series of questions that explore how we could better assess students' contributions to and accomplishments in mathematics: How can teachers assess the social processes present in mathematics classrooms and the value that students add to each other's learning when they explain concepts and deepen conversations in class? How do teachers know whether their students are experiencing joy in mathematics classrooms or experiencing agency in directing their own learning? How are students using mathematics as a tool in real-world problem solving? Where are the "mathematics spaces" in schools besides the classroom where connections are made to mathematics learning?

Ortiz shares an example of a school grounding group work in the principle of Ujima, or collective work and responsibility. Determining how to assess students based on their contributions to the collective and as a collective provides a new way of understanding student learning. Likewise, Miller-Cotto highlights research that calls for multiple forms of assessment and formative assessment aligned with student interests.

#### **Curriculum and Pedagogy**

As the vehicle through which the relationship between teaching and learning comes to life, curricular choices have a lasting impact in terms of what students take from their time in school. Just as important as curriculum is how teachers convey content to students through their pedagogy.

Curricular and pedagogical supports are necessary for teachers attempting to create more inclusive classroom environments. Without supports that develop and grow critical consciousness among teachers, curricula and pedagogy risk creating harmful environments for the most marginalized students and reinforcing racist and discriminatory hierarchies for all students. Curriculum content that lacks representation of marginalized and minoritized student groups conveys the message that these groups have made little to no contribution to mathematics and devalues important cultural ways of knowing that are different from white, cisheteronormative, middle class perspectives. For instance, as of 2020, only five states have passed an Inclusive Curriculum Law requiring schools to teach LGBTQ history.

In addition to honoring the contributions of marginalized and minoritized groups, these types of legislative actions can lead to classroom experiences that contribute to marginalized and minoritized students' sense of belonging to school. However, without a pedagogical stance that affirms students' lived experiences and works to support student agency in challenging oppressive systems that marginalize their experiences, these types of curricular efforts become one-off endeavors.

<sup>&</sup>lt;sup>24</sup> Student Voice in Mathematics Instruction. (2019, October 15). Panel at the Mindset Scholars Network Funder Briefing, Seattle, WA.

<sup>&</sup>lt;sup>25</sup> Nasir, Na'ilah S., et al. (2014). Mathematics for Equity: A Framework for Successful Practice. Teachers College Press.

A common understanding of Freire's critical pedagogy is the difference between the "banking" model of education, in which students are considered empty vessels for teachers to fill, and the "problem-posing" model of educati on, in which teachers work with students to understand problems and overcome them.

The use of more intentional, critically conscious pedagogical approaches is needed in confronting the structures that marginalize students. A critically conscious pedagogy in K-12 education generally, and in mathematics, specifically, asks educators to be cognizant of, and respond to, the multiple systems of oppression that marginalized students face. Friere's critical pedagogy has been influential among scholars concerned with creating more just and humanizing learning opportunities from university settings (i.e. bell hooks) to K-12 settings (i.e. Duncan-Andrade and Morrell).<sup>26</sup> Critical pedagogy calls for an agentic style of learning in which teachers work with students to understand the realities of their lives and ways to liberate themselves from oppression. A common understanding of Friere's critical pedagogy is the difference between the "banking" model of education, in which students are considered empty vessels for teachers to fill, and the "problem-posing" model of education, in which teachers work with students to understand problems and overcome them. With the stance and strategies of critical pedagogy, teachers are able to bring the lived experiences of the most marginalized students into the classroom making it a testing ground of how to critically evaluate and engage the world.

Curriculum choices are indeed impacted by policy, but are enacted by teachers in classrooms. If teachers don't believe or aren't aware that students need to see themselves represented in the curriculum or are uncomfortable with identity-focused, justice-focused, or critically conscious work, then the mere use of different curriculum will not suffice to create a change in the experiences of marginalized and minoritized students.

#### **Teacher Knowledge and Beliefs**

Enacting new ways of teaching and assessing students means teachers need support to understand their work differently. It is a common refrain that teachers teach the way they were taught. Reliance on the supposed neutrality of mathematics makes it especially critical to think about transforming teacher knowledge and mindsets in mathematics to create better classroom environments for both students and teachers. At the Mindset Scholars Network event mentioned above, Elham Kazemi noted that preparation and professional learning for teachers that covers mathematics content is often disconnected from professional learning that covers how students learn and how structural and institutional factors shape opportunities and learning. This disconnection produces classroom settings and interactions that perpetuate exclusionary and deficit-based practices with students. Pre-service programs and ongoing teacher professional development are critical levers for supporting teachers in creating psychologically safe classrooms that send clear messages to students about their value as mathematicians and their status as an essential member of the classroom community.

Bolstering teacher knowledge and beliefs in several key areas is likely to transform their interactions with students, and also lead to instructional practices that engage students in building mathematics identities. For middle grades teachers, perhaps most important is understanding adolescent development and its intersection with marginalized identity development (in particular, racial and ethnic identity) during this crucial stage. This period is accompanied by new opportunities for learning, but also challenges that are heightened for students who must navigate changes in their bodies and relationships as well as navigate identities that do not conform to white, cisheteronormative, middle class ways of being.

Teachers also need support in understanding how to build developmental relationships with young people and how to foster learning environments that allow for the co-construction of knowledge.

As articulated by the Search Institute, developmental relationships create opportunities for young people to experience success in many different areas of their lives, particularly academically.<sup>27</sup> Adults are able to support young people through developmental relationships when they express care, challenge young people to grow, provide support, share power, and expand possibilities. Further, developmental relationships between teachers and students give rise to opportunities for the co-construction of knowledge. When teachers are curious about student thinking, they structure opportunities for students to share their informal and home knowledge that can lead to classroom learning based on students' experiences and interests.

<sup>27</sup> "The Developmental Relationships Framework." Search Institute.

<sup>&</sup>lt;sup>26</sup> Freire, P. (1970). *Pedagogy of the Oppressed*. Penguin.

## DEFINING, ELICITING, AND RECOGNIZING SUCCESS IN MATHEMATICS FOR MARGINALIZED STUDENTS

Building equitable and inclusive mathematics learning environments that truly work for all students requires us to reconsider the value we believe mathematics holds for our students, how it is taught, and what success can look like in mathematics classrooms. As a system, we have tried approaching mathematics from a neutral and values-free perspective, devoid of cultural meaning-making and relevance to students' lived experiences, and learned that such an approach does not work for the multitude of students that comprise our U.S. student population. Centering the very student experiences that have long been ignored is key to reimagining a new approach to understanding the discipline and teaching and learning of mathematics. The research insights of the IME fellows and faculty contributors

lay the groundwork for envisioning more equitable and inclusive mathematics environments. Through their insights we are compelled to consider changes via three critical levers: assessments, curriculum and pedagogy, and teacher knowledge and beliefs. These levers respond to and depend on each other. New forms of assessment are needed to articulate a richer, more inclusive definition of success; culturally relevant and responsive curriculum and pedagogical philosophies are needed to elicit success from students who are currently most likely to be excluded from mathematics learning; and critically conscious teachers are needed to recognize students' success. When we look across research disciplines and commit to approaching mathematics from an equitable and inclusive perspective, we give all students the opportunity to exist and thrive as their whole selves in mathematics environments.

TERMS	
Critical consciousness	Understanding and taking action against inequities
Critical pedagogy	An agentic style of learning in which teachers work with students to understand the realities of their lives and ways to liberate themselves from oppression
Co-construction of knowledge/dialogic instruction	Eliciting student participation in the construction of learning
Equitable noticing	Bestowing explicit positive and affirming attention upon marginalized and minoritized students
Marginalized	Systematically excluded because of oppressive social structures
Mathematics identity	A sense of self in which one feels empowered to engage in mathematics
Minoritized	Systematically denied power because of oppressive social structures
Positioning	Interactions that allow for and prevent one from asserting one's identity
Proactive confrontation	Demonstrating how actions might be biased toward marginalized students and remedi- ating those actions before they occur
Resistance	Subverting the norms of participation or leveraging alternate forms of participation
Targeted universalism	Universal goals with targeted approaches for different subgroups