KnowledgeWorks

Futures Affecting Math Education

Widening the Lens on Change

Introduction *An Inequitable Equation*

In both clear and invisible ways, math is a building block of every structure, innovation, and creative pursuit. A strong foundation in math can unlock countless opportunities for young people.

Despite its clear importance to society and individuals, math education in the United States falls short in terms of quality, accessibility, and relevance, particularly for Black and Latino students and students from low-income backgrounds.

Improving math education has been a long-held goal of many leaders and changemakers, and the continued struggle to make equitable progress is not for lack of trying. However, many efforts to change the ways in which math is taught and learned treat math education as being entirely separate from the contexts in which it exists. In reality, what happens in math classrooms is only part of the equation. Math education is also shaped by changes happening within and outside education and by the daily issues that affect people's lives.

As we consider how to improve math education and aim to envision a different future for it, we need to engage with this broader landscape. We need to explore how things that could happen outside math education might influence what happens within it. Without this wide lens, we run the risk of attempting to effect change in isolation. Time and again, that approach has led to failed efforts toward meaningful change or, worse, to harm against the people whom the efforts aimed to support.

This ten-year forecast on futures affecting math education will help people seeking to improve math education avoid taking an overly narrow view. Equipped with an understanding of forces of change outside math education and with an awareness of future possibilities, changemakers can seek to improve math education in the same way people experience it: linked with the world around it.

About This Forecast

This forecast focuses on improving math instruction and outcomes for all students, especially Black and Latino students and students from low-income backgrounds. This effort aims to demonstrate that math is for everyone and to highlight math's power as a tool to prepare all learners for the futures that they envision for themselves.

This forecast looks ahead ten years to explore possibilities affecting math education. It is organized into three sections.

1. **Drivers of Change Affecting Possible Futures of Math Education**: This section describes five drivers of change. These are major societal shifts that have the potential to shape futures affecting math education.

2. **Futures Affecting Math Education**: This section presents four possible futures affecting math education. These possible futures show how the drivers of change could combine to create different contexts for math education.

3. **Issues to Consider for Improving Math Education**: This section presents four areas for reflection and potential action that promise to advance efforts to improve math education.

By examining current drivers of change, possible futures, and issues for consideration, people will be able to make math more relevant and engaging for all students in the context of a dynamic world. This broad perspective can help ensure that today's decisions are strategic and durable and can help prepare people who are working to improve math education to respond effectively to change.

A companion piece, _Modernizing Math: Envisioning Liberatory Math Futures_ by Optimistic Design, a sub-division of Substantial, articulates a vision for the future of math education informed by what lived experts—students, parents and caregivers, and math teachers—and subject matter experts value and prioritize. It includes recommendations for how people across the education landscape can start moving toward this vision.

Together, these two resources suggest ways forward for math education: what seems ideal and how we might get there, plus what we should keep in mind and address as we work to provide the math experiences that kids deserve and support them in succeeding in school and life.

Drivers of Change Affecting Possible Futures of Math Education

Change is something that we create and is also something that happens to us.

In our efforts to shape the future of math education, we must cast a wide aperture on drivers of change that could affect it. These drivers of change are societal shifts that could impact the future of math education, presenting both opportunities and challenges.

This section describes five drivers of change. Their descriptions outline trends and other evidence of change:

- **Accelerating Technologies:** How emerging technologies could influence our lives

- **Inescapable Climate Crisis:** How we could be affected by, and respond to, a changing planet

- **Diversifying Education:** What a widening set of approaches to learning could mean for students and society

- **Contested Society:** How people's shifting relationships with one another and with institutions could affect social structures

- **Rebalancing Economics:** What challenging and evolving conditions could mean for how the economy functions

Accelerating Technologies

Technological advancements have long impacted human behavior. As technological developments unfold, they leverage one another by bringing about the conditions required to allow even more advancements. In 2023, artificial intelligence (AI) dominated the headlines and the collective imagination after the public was able to experience firsthand the power of ChatGPT and other generative AIs to redefine how people learn, work, and even value human intelligence and creativity.

The hype around generative AI, along with the number of notorious tech companies that have been contracting or collapsing, have also sparked renewed questions about what policies and regulatory bodies should hold these businesses and the individuals working for them accountable. While AI and other emerging technologies such as quantum computing, virtual and augmented reality, and blockchain have immense potential, they could also exacerbate inequities by failing to represent diverse groups, amplifying human bias, and fabricating the videos and images known as deepfakes. They also have the potential to continue to concentrate power within relatively small, wealthy, and unregulated groups. Companies' tendency to prioritize profits over people could make it hard to mitigate such risks.

Inescapable Climate Crisis

Recent polls have found that an increasing number of people in the United States feel alarmed by climate change as the number of extreme weather events continues to surge. The excessive burning of fossil fuels and other human activity have irreversibly damaged the natural environment for people and other species. These changes are not only irreversible; in most cases, they also accelerate one another, triggering dangerous feedback loops across our ecosystems, in which everything is connected to everything else.

Despite the magnitude of these threats, places and people are and will be impacted by climate change in different ways and at different times. As a result, there will not be one uniform story for making sense of the climate crisis. In particular, low-income communities and communities of color are, and could continue to be, disproportionately impacted by it. The impacts of climate change could include food and supply chain disruptions, water usage restrictions or fines, and increasing public expenditure on responses to natural disasters. But there is hope: Feeling alarmed has driven more people, especially in younger generations, to learn about sustainable practices and to seek sustainable alternatives.

Diversifying Education

Education has seen a diversification of approaches to, and formats for, teaching and learning, from kindergarten through postsecondary education and beyond. This diversification has been technological, pedagogical, and cultural. For example, technological enhancements such as online, data-informed and mixed-reality learning have presented themselves as being among the most innovative solutions that education technology companies have to offer. At the same time, content-focused approaches such as interdisciplinary, social-emotional, and culturally responsive learning have been highlighting areas often overlooked by dominant curricula in the United States, and the increasingly widespread use of personalized learning has been seeking to create educational experiences tailored to every student. The number of approaches to education might continue to expand, leading to more polarization and to a more varied, but possibly incoherent, landscape. Every approach will be put to the test as the United States transitions to a more diverse student body—with regional differences—and as its population ages.

Contested Society

How societies and social groups are governed and organized plays a major role in the collective imagination. These factors can make it feel hard to change things for the better or can give people hope of improving life for themselves and others. In recent years, more and more people living in the United States have questioned the role of government and have lost trust in both public institutions and public-private partnerships. The vast and hastened spread of disinformation through social media has fed the intense political polarization and cultural wars that now permeate people's public and private lives.

Nonetheless, many people have been seizing the opportunity to demand justice, dignity, freedom, and financial reparations as non-Hispanic whites become a minority in the United States and as a national reckoning around the rights of Black, Indigenous and other people of color gains momentum. Overall, the health of American democracy has been declining as the country has faced systemic threats domestically and abroad and has teetered toward autocracy.

Rebalancing Economics

The U.S. economy is seeking stability as demographics, values, and technologies clash with established approaches and as the impacts of the COVID-19 pandemic continue to reverberate. An aging population is straining already limited resources. People have been returning to cities as employers have dropped pandemic flexibilities and as stimulus payments and other benefits have ended. Despite a renewed push for diversity, equity, and inclusion in the workforce, women's participation rates remain lower than before the pandemic. Advances in AI are driving fresh warnings of technological displacement, especially for knowledge and creative workers.

The union movement has been especially active of late as workers in disparate sectors have sought and secured better working conditions in the face of ongoing structural issues limiting workers' options. While national security concerns have been leading toward a push to re-shore critical industries and to build redundancies into supply chains coupled with a debate about how best to transition to next-generation industries has been raging, more and more economic experts have begun considering the viability of a variety of post-capitalist economic models and priorities, such as the circular and well-being economies.

Futures Affecting Math Education

The future can turn out in countless ways.

Exploring a range of possibilities can help loosen the grip that the status quo holds on our minds and imaginations and can broaden our perspectives. From there, we can make strategic decisions and pursue change informed by the changing context in which math education operates and people carry out their lives.

This section presents four possible futures affecting math education:

- **We Are the Best Technology:** What if math education were highly personalized and technologically mediated but the most meaningful learning experiences emerged from solving real-life problems in tight-knit communities?

- **Profit and Loss:** What if math were a critical element of economic participation and national security and people learned math throughout their working lives?

- **Strengthening the Nodes:** What if a robust network of out-of-school time math education providers, along with new approaches to technological development and motivations for adoption, served as vehicles for social connection?

- **The Worlds We Build:** What if culturally relevant virtual worlds and exploratory pedagogical approaches unlocked youth-led math inquiry and youth action on climate issues?

Each future possibility contains four elements.

The four future possibilities do not form a comprehensive list, nor are they predictive or necessarily aspirational. Rather, they enable us to explore a range of possibilities, which can help us develop new insights and approach change with a wide-angle lens.

1. **Assumptions about the Drivers of Change in This Future:** This element describes key assumptions about how the five drivers of change could play out, based on trends and signals of change. Each driver of change is labeled as "current trajectory," "medium shift," or "high shift." A driver of change on the current trajectory will have played out in the way many would expect based on current trends. A driver of change with medium shift will have unfolded differently, shifting somewhat from that current trajectory due to accelerated change or a modest disruption. A driver of change with high shift will have played out very differently than most would expect, veering considerably from the current trajectory due to highly accelerated change or a major disruption. Because the exact trajectory of change is unknowable, each future possibility is based on one plausible combination of assumptions about the way the drivers of change highlighted in this forecast might unfold.

2. **Description of This Future:** This element describes the resulting image of the future in broad strokes, exploring how the key assumptions about the drivers of change interact and characterizing the general landscape of this possible future.

3. **A Personal Education Experience in This Future:** This element describes in more detail one person's experience of this possible future, with a focus on how they are experiencing math education.

4. **Math Education in This Future:** This element describes the state of math education in this possible future. It details features such as learners' attitudes toward math, educational structures and environments, relationships between learners and educators, and the connections between math education and the broader world.

We Are the Best Technology

What if math education were highly personalized and technologically mediated but the most meaningful learning experiences emerged from solving real-life problems in tight-knit communities?

People are trying to get by in an ecologically unstable and technologically saturated environment. They rely primarily on one another to meet their needs. A large percentage of public funds now goes toward rebuilding infrastructure after environmental disasters.

In many communities, public schools are in session two days a week, and students work with highly personalized AI apps to complete and log their remaining instructional hours. These cities and towns often came to this arrangement reluctantly. However, funding is scarce, and keeping schools open and human educators on staff five days a week is a luxury that many places cannot afford. Students' technological companions help them track progress on their developing skills, support them in completing assignments, and engage them in basic reflection on their learning. Vendors promised that these technologies would promote complex thinking and discovery, but students' use of them has only reinforced their perception that math is mostly about following an established process and finding correct answers. Educators have faced a steep learning curve in understanding what to trust these tools to do.

Assumptions about the Drivers of Change in This Future

High Shift

Accelerating Technologies: Artificial intelligence (AI) and data capture are at a point where "digital twins," or ultra-personalized assistants, are widely accessible and used.[1]

Medium Shift

Contested Society: The federal government is largely ineffectual,[2] and people look to their local communities to solve problems.[3]

Rebalancing Economics: People go to work and school fewer than five days a week.[4]

Inescapable Climate Change: Many climate-vulnerable communities are continuously rebuilding after storms and other natural disasters.[5]

Current Trajectory

Diversifying Education: A crisis-level teacher shortage[6] has stalled most innovations in public education,[7] leaving people to navigate an outdated, fragmented system.

In other sectors, adults are also working fewer hours. Like students, they rely on AI digital twins to handle many rote tasks and to help them develop the new skills needed to keep their communities functioning. People have a complicated relationship with their technological partners; they rely heavily on them but crave in-person connection. They also recognize that the resources needed to produce and maintain these tools are contributing to environmental harm.

Though many people are struggling, many are also finding purpose as they try to keep their neighborhoods and cities livable. Community meeting attendance is at an all-time high, and residents are using time that they had previously spent working and going to school to collaborate toward solving the real problems that they face. People are reporting increased levels of connection and engagement with their neighbors. This strong sense of community, not the technology that they use every day nor the paltry support that they receive from larger units of government, is many places' best asset and hope. People are seeking sustainable ways to build resilience even as they anticipate worsening weather events and climate shifts and as they grapple with their own contributions to planetary deterioration through their reliance on technological tools.

A Personal Education Experience in This Future

When Efrain decided to become a teacher, he never imagined how much of his day would be spent managing technology and correcting its errors. That's not what he was trained to do, nor does he have the time with the cutback on working hours. No doubt Digital Twin can tailor his students' learning more specifically than he ever could, but it still makes so many mistakes. Given people's reliance on this sometimes-undependable tool, the shared understanding of "facts" is continuing to diminish, even in math, where answers were once considered indisputable.

But Efrain felt the energy of teaching during his in-person check in with Jackson, where they discussed the next steps in Jackson's learning plan. He is one of a few students who are taking the initiative to use the personalization that Digital Twin offers to meet the standard learning targets through their real-life interests. Efrain wishes that he had the time to help more students realize the potential for the somewhat soulless-feeling Digital Twin to help them grow skills they really care about, but he is one of the only secondary math teachers in the area.

Jackson has used some of the time when he would have normally been in school to follow his passion and serve on the neighborhood's community garden committee, which has been working to deepen its understanding of sustainable food sourcing and land management practices. Jackson is part of a sub-group working to understand a new garden plot's soil quality. He and Efrain set up the next learning steps in Digital Twin so that Jackson could practice calculating element ratios and soil amendment needs and help adults on the sub-committee do the same.

Even knowing that he will need to triple check Digital Twin's support for Jackson and that there were three other students waiting to meet with him to figure out glitches in Digital Twin, Efrain still felt like today was a good day. When he was learning math as a student, all he wanted was a teacher who understood his life and could make the numbers and equations mean something in relation to it. His students certainly have that, even if they do not get nearly enough of his time.

Making Sense of This Future

- *What aspects of this future stand out to you? What do they make you think about?*

- *What opportunities and challenges related to math education do you notice in this future?*
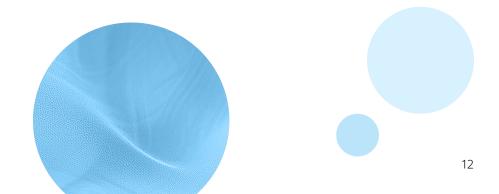
Math Education in This Future

- Technology has enabled math learning journeys to be highly adaptive to students' needs and aptitudes, but its transactional sort of personalization does not prioritize support for students in developing their math identities, interests, or agency.

- Teachers are overstretched and burned out. They focus mainly on the logistics of their students' learning, not on improving their own practice or student outcomes.

- Relevance in math education is uneven, and no system-wide supports ensure that math is specifically relevant to Black and Latino learners and learners from low-income backgrounds. Though technology and schedule flexibility enable students to

apply their learning to real-world problems and some students do so independently, school-based math education and the real-life application of math continue to be highly separate spheres. Educators lack the capacity to support most students in connecting content standards to their own lives.

- People's reliance on sometimes-faulty AI tools means that some facts, such as answers to math equations, can be topics of debate. The disagreement creates challenges for educators, even in cohesive and connected communities.

- Many adults need to revisit math as they work to build community resilience. They need to understand statistics, probability, geometry, engineering, and other disciplines to keep things running as smoothly as possible in uncertain and under-resourced circumstances. In the absence of a formal adult education infrastructure, adult learners use technology and rely on younger students for support.

Making Sense of Math Education in This Future

- *What else might be true of math education in this future?*

Profit and Loss

What if math were a critical element of economic participation and national security, and people learned math throughout their working lives?

The American political landscape has flattened. It is no longer this party or that one, the haves or the have nots, at least not to the degree as was common at the peak of divisiveness and income inequality in 2024. Fed up with federal governmental gridlock and with the swing between lackluster democracy and the specter of autocracy, people are getting more done due to emerging approaches to governance.

When the Department of Defense elevated economic inequity and dependence on the global economy as national security concerns, politicians and businesses listened. They began to re-shore more industries and to incent a rebirth of manufacturing on U.S. soil. This shift brought back jobs, though working in manufacturing means something different than it did in the 1980s, having become much higher tech.

The use of generative AI has, surprisingly, helped level the workforce's skills. Workers have access to robust postsecondary training and to reskilling and upskilling opportunities, supported by the government and industry push for a strong, accessible U.S. economy. However, these opportunities often favor the short-term workforce needs of technology and manufacturing companies over long-term career skill development for workers or the interests of the knowledge and creative industries. Industry has paid particular attention to closing opportunity

Assumptions about the Drivers of Change in This Future

High Shift

Contested Society: Voters support third-party candidates in meaningful numbers,[8] and many local governments have been moving away from winner-take-all elections.[9]

Rebalancing Economics: People participate in strong regional economies, working alongside robotic companions and receiving supports to reskill and upskill.[10]

Medium Shift

Accelerating Technologies: AI is embedded in daily work, learning and life functions,[11] but its quality[12] and oversight are uneven.[13]

Diversifying Education: Public schools and districts have the resources, structures and motivation to adopt evidence-based practices,[14] though learning is highly oriented toward economic productivity.[15]

Current Trajectory

Inescapable Climate Change: Life expectancy in the United States continues to drop, exacerbated by extreme climate events.[16]

gaps for workers of color and immigrant workers as the population has continued to diversify. Still, oversight of workforce development AI is uneven. Many people's work lives feel highly transactional, but they now enjoy a higher standard of living.

Education and industry are mutually reinforcing and rely on each other to meet their respective aims. K-12 education, in particular math education, is now largely standardized around evidence-based practices. It supports students in developing the basic skills needed for any job. These skills include core math and technical skills, as well as the adaptable learning skills needed to keep up with an ever-shifting technology landscape and job market. Beyond these basic skills that everyone needs, students follow specific pathways based on their workforce interests and aptitude in certain areas. Because different pathways prioritize different skills, students of the same age may have very different learning targets. Climate action has taken a backburner to economic action, and leaders are reluctant to acknowledge and address rising mortality due to extreme climate events, though grief and loss cast a pall over a sense of economic stability.

A Personal Education Experience in This Future

Maura mostly likes her robotics class. Her mentor through Black Women in Robotics, Vee, had the same teacher when she was in school, and she has advanced quickly in her career. Vee is taking a paid Learning Sabbatical from work soon so that she can upskill and return to lead the team at her company that will be working on a therapeutic AI companion for children experiencing anxiety. Vee has arranged for Maura to join her team as an apprentice given Maura's interest in mental health and skills in robotics. Vee is doing everything she can to

ensure that her mentee can shape the future of these technologies, not just use them in her job. Maura has good teachers who are well supported in their own ongoing learning to give their students the instruction and coaching that they need to be successful. Nonetheless, she feels perpetually stressed. Her preferred industries are changing so quickly that new competencies are always being added to her learning pathway. She worries about the future but does not feel as if most people want to hear about it.

In her statistics class, they calculated their town's life expectancy. It has been slowly dropping over time—with larger dips coinciding with particularly devastating disasters—but the class did not talk about how that felt or what that meant beyond its implications for the workforce and health care systems. When half the town burned down in a wildfire last year, people were proud of how prepared they were to rebuild with all the skilled workers and high-tech equipment, but Vee was the only one with whom Maura could share her real feelings about having lost so much.

Maura persists, knowing that more ease and stability for her family are on the other end, but she sometimes wonders whether she is doing what she wants or what she is expected to want.

Making Sense of This Future

- *What stands out to you about this future? What does it make you think about?*

- *What opportunities and challenges related to math education do you notice in this future?*

Math Education in This Future

- Math education is explicitly tied to economic participation and productivity. Learning math is a lifelong activity, with workers learning new skills on the job and in focused periods of re-learning.

- K-12 math curricula are tightly linked to basic job market needs. As those needs shift, curricula shift alongside them. Given the tight relationship between employers and education, structures have adapted to make room for this flexibility.

- In an environment that relies on them to prepare students for specific jobs, teachers play a critical role in making the links between the economy and education work. They have strong professional development support, including their own paid learning time, and are respected for their high levels of adaptability. Their high-pressure roles do not always give them the chance to exercise creativity and agency.

- Artificial intelligence and robotics play large roles in the economy, so learners have high levels of support and access to learning opportunities related to using these technologies. However, the learning pathways related to designing, developing, and shaping the future of those industries are exclusive and are still dominated by White, male, and wealthy students.

- Black and Latino students and students from low-income backgrounds have much higher access to high-quality math instruction and supports than they used to, as companies understand the economic benefits of diversifying the workforce given the shifting demographics of the country and commit significant resources to doing so. However, what math is taught, how, and by whom is driven by short-term workforce needs, leading to a lack of attention to cultural responsiveness and belonging and to other long-term concerns, such as climate instability and environmental injustice.

Making Sense of Math Education in This Future

- *What else might be true of math education in this future?*

Strengthening the Nodes

What if a robust network of out-of-school time math education providers and new approaches to technological development and adoption were vehicles for social connection?

The U.S. Congress has been busy. After nearly a decade, the SECURE Act was finally passed and signed into law. It provides the everyday support that working families had long needed and which lawmakers had repeatedly failed to deliver. As the U.S. population has continued to diversify and age, health care, housing, and caregiving gaps and needs have increased. This legislation attempts to address those issues, among others.

When generative AI burst onto the scene, its proponents promised that it would transform every industry, save childcare, improve our social relationships, heal the planet, and so much more. Not surprisingly, those promises fell short. Generative AI is everywhere, of course. But with the planet continuing to warm, families continuing to struggle, and loneliness and mental health crises persisting, people stopped believing that any technology was coming to save them. Instead, they demanded practical and tangible ways to get relief.

Assumptions about the Drivers of Change in This Future

⚡ High Shift

Accelerating Technologies: Discussion of treating AI as an essential public utility becomes mainstream in policy and research circles.[17]

Rebalancing Economics: Congress has passed a package of policies that attempt to strengthen the social safety net, including universal childcare, paid family leave, student debt relief[18] and supports for communities to incent social connection.[19]

〰 Medium Shift

Diversifying Education: Public education has eroded deeply,[20] but community-based and after-school providers are finding creative ways to help pick up the slack.[21]

→ Current Trajectory

Contested Society: Social, cultural, and faith-based institutions that support social connection play a less and less prominent role in people's daily lives,[22] while loneliness and mental health crises persist.[23]

Inescapable Climate Change: Climate instability disrupts, but does not fully destabilize, everyday life.[24]

Now Congress is holding hearings to understand more about how AI might be treated as a public utility that would be owned, regulated, and priced in ways that would allow stronger oversight and equitable access. Dogged researchers and whistleblowers have pushed this conversation even further, foregrounding issues around inclusive, equity-focused development, and deployment of generative AI. Tech companies are working to earn back public trust after years of failed promises to regulate themselves.

Congress' next focus will be public education, for which both support and funding have continued to drop. Education savings accounts have been part of the discourse for as long as anyone can remember, but a new round of experts will be sharing ideas for how such accounts might prop up both strong community-based learning organizations and public schools at the same time. Skepticism about this approach remains high, but the players acknowledge the need for a robust public education infrastructure that can support belonging and peer connection as well as the need for a supportive community-based learning ecosystem where people can join together to form social bonds. The changing U.S. population makes the effort to enable connection across lines of difference all the more urgent. The continued deterioration of mental health in the United States has finally become too important to ignore, and leaders are willing to come to the table to work toward a common solution.

A Personal Experience in This Future

Tamara remembers the lonely days in their old job, doing the engineering that they loved but feeling as if everything had gone wrong along the way. By the time they left that job, the work did not have much meaning and they felt as if they were contributing to social problems rather than solving them.

Now Tamara is preparing to testify in front of Congress. Tamara will be sharing the ideas and innovations that they and their colleagues have spent years refining, the ones that show that truly community-centered, inclusively developed AI is possible and can positively contribute to society, as so many people had promised back in its infancy.

Tamara's greatest pride, though, is that two youths whom they are mentoring, Jacqui and Ezra, will be there too. Tamara's student debt relief and other safety-net policies have allowed them to dedicate significant time to Mycelium, the local learning space that aims to support students of color in building social ties within their communities through culturally relevant math and technology programs. Using ethically sourced datasets, the youth and Mycelium mentors have been developing AI-based resources for disconnected youth in their communities. Some of the youth who participate in Mycelium are not particularly interested in math and technology, but many of them feel isolated, and the learning space is a place with caring adults and peers who understand their lives. So, the youth continue to show up. After seeing possibilities for how technology can connect people

when designed for that purpose and not simply for profit, they are overcoming some of their disillusionment with it. Neither Jacqui nor Ezra wants to pursue a career in tech, but Ezra is interested in studying social work and is confident that the experience that he is getting at Mycelium will help him support people better.

The need to help people connect is so urgent—the loneliness epidemic just seems to be getting worse—and Tamara, Jacqui, and Ezra must help lawmakers see that the ways technology, especially generative AI, is developed and regulated will matter a great deal in whether society comes together or falls apart.

Making Sense of This Future

- *What stands out to you about this future? What does it make you think about?*

- *What opportunities and challenges related to math education do you notice in this future?*

Math Education in This Future

- Math content and curriculum in public schools have not changed much since the 2020s.

- A robust network of out-of-school time and community-based learning providers is offering culturally relevant and engaging math education that is guided by student interests and which focuses on relationship building.

- School and community-based learning environments are seen by many as the last places left that regularly connect people to one another. Skill-building in every discipline, including math, is valued primarily as a vehicle for knitting society together.

- In the face of economic reconfiguration, policies that reimagine and strengthen the social safety net enable more adults to engage in mentoring and teaching youth in out-of-school settings.

- The economic and employment argument for math education has weakened given strong distrust of technology companies. Math, as a prerequisite for a career in technology, is not compelling enough for many students to want to pursue it. Some educators are working to show young people the positive ways in which math and technology can serve communities.

Making Sense of Math Education in This Future

- *What else might be true of math education in this future?*

The Worlds We Build

What if culturally relevant virtual worlds and exploratory pedagogical approaches could unlock youth-led math inquiry and youth action on climate issues?

Some students and educators are using powerful and accessible virtual and augmented reality tools to explore big questions about the world as part of their learning journeys. However, what and how students learn varies widely depending on where they live. Political divides; continued racial and economic segregation in housing and schools; people's tendency to sort themselves into like-minded communities; and increased local control over standards, curriculum, and assessment have led to vast divides on what content and skills are valued and how much agency learners and educators have in designing learning experiences.

Education remains contested: As has been true in the past, adults take out their frustrations about the unpredictable and ever-changing economy and job market on education and educators, maligning certain disciplines and educational approaches. Math, science, and the arts have been under particular attack in some parts of the United States. A growing narrative asserts that these subjects are no longer relevant for most jobs given AI's ability to solve complex problems, write, and create. In addition, the increasingly visible use of math to expose inequities and injustices and to design solutions has led to a belief in some circles that math is being used to push political agendas.

Assumptions about the Drivers of Change in This Future

High Shift

Inescapable Climate Change: An influential youth movement toward planetary healing and equity[25] has led to environmental reparations for communities of color and for low-income communities that have been disproportionately affected by climate change.[26]

Medium Shift

Diversifying Education: Decisions about curriculum, standards and assessment are highly localized.[27]

Current Trajectory

Accelerating Technologies: Virtual and augmented reality and immersive worlds[28] are accessible and ubiquitous.[29]

Contested Society: Political and cultural differences across cities and towns in the United States[30] are as wide as they have ever been.[31]

Rebalancing Economics: The economy is volatile[32] and precarious for most people,[33] with knowledge[34] and creative work[35] no longer being safe paths to economic stability.

In contrast, respect for the teaching profession has increased in some places. When that is the case, teaching has become one of the last stable fields of employment and a profession where people can innovate and develop their skills. As a result, the field is growing after many years of decline. In particular, Black and Latino college graduates are being drawn toward education in those places because it can enable them to explore technology, learning science, inquiry, identity, and community resilience.

Some of those educators were recently recognized for their facilitation of a years-long learning experience with students across the country who connected in virtual worlds to explore the effects of climate change. Their extended deep dive into statistics, environmental science, Geographic Information Systems, and climate modeling yielded powerful research showing the disproportionate effects of environmental disasters on Black and Indigenous communities and other communities of color. Their research and advocacy, which they advanced primarily in virtual worlds, was credited with sparking a youth-led movement that spread into the physical world and which led to environmental reparations in some states.

A Personal Experience in This Future

Joel felt excited to represent his "Math for Community, Not Inequality" hub at the Governor's Awards ceremony, but he felt nervous about the prospect of explaining the virtual community to adults who had not been on this journey. How could Joel explain that the community's learning and work were not just about environmental injustice but also about the design of new economic models? About how art and math are inextricably linked? About how math has been used to harm people in the past and how it can be used to heal instead? About how thinking about the future can be grounded in their identities and those of their ancestors, as happens in Afrofuturism?

Joel would probably just stick to talking about the environmental reparations project since this type of learning seems to blow the minds of people who have not experienced it. Joel could not believe what his friend who had moved away had told him about his new school. That school uses virtual reality and inquiry-based learning, too, but the topics that students can explore became really restricted after some parents had complained that the teachers had been indoctrinating the students, even though the students had been the ones choosing what they wanted to learn more about. Joel feels grateful to have so much more leeway in what they can explore, and he is glad that he can stay connected to his friend in the virtual space, even when their nearby cities feel worlds apart.

He is hoping to make some connections with technology developers or artists at the awards ceremony since those are the two fields he is most interested in, but Joel also knows that he could gain a lot of experience in both areas if he started in teaching at his own high school after college first. One of his teachers had come to education after a long career in graphic design and said that teaching at this school was the most creatively fulfilling work that she had ever been able to do.

Making Sense of This Future

- *What stands out to you about this future? What does it make you think about?*

- *What opportunities and challenges related to math education do you notice in this future?*

Math Education in This Future

- Highly localized decision-making about standards, curriculum, and assessment has led to wide variation in educational experiences across the United States. Some young people bridge these divides through virtual worlds.

- The public discourse about how math is used and applied in society—and whom those applications benefit and harm—is influencing math instruction as well as students' and families' demands about math education.

- Political divides have meant that some communities are rejecting math and science education on the grounds that they push political agendas.

- Teaching offers a stable career path in an unpredictable environment and affords people opportunities to innovate and explore multiple disciplines. It also is a field where people can find a cultural fit, no matter their political leanings or personal values.

- Black and Latino educators are leading cutting-edge learning designs and experiences that weave deep math learning with high levels of cultural and social relevance. Many are using Afrofuturist frameworks, which affirm learners' ancestries, identities, and experiences and which draw upon those assets to spark deep and creative thinking about social transformation.

Making Sense of Math Education in This Future

- *What else might be true of math education in this future?*

Issues to Consider for Improving Math Education

Exploring future possibilities can open our eyes to issues that we might not consider when looking only at today's circumstances. This widened perspective can open new avenues for reflection and action.

This section presents four issues for changemakers to consider as they work to improve math education for Black and Latino students and students from low-income backgrounds:

- **The Purpose of Math Education**: How we might clarify the purpose of math education for individuals and society

- **Mindsets about Technology**: How we might reflect on and shift our beliefs about the role of technology in improving math education

- **The Environment Surrounding Math Education**: How innovation in math education could account for broader systemic realities

- **Math Education as a Source of Healing and Support**: How math education environments could be designed for healing and support

Each issue contains three elements, as described below:

- **Issue Overview**: This element describes the issue and why it matters for math education.

- **Tracking This Issue in the Possible Futures**: This element recounts aspects of the four possible futures that relate to the issue.

- **Applying This Issue to Your Context**: This element poses three questions that changemakers can ask themselves and other constituents to begin to explore the issues with specificity to their circumstances.

Issue Overview:

The Purpose of Math Education

Learners regularly ask why they are learning math.

Changemakers should consider this question and should engage young people, educators, and other constituents in exploring answers to it. Often, pedagogical approaches, curricular choices, or instructional materials dominate conversations about math education. While pertinent, discussion of these topics should be informed by a broader understanding of why math education matters to individuals and society and how it could be meaningful to people's lives.

Young people, educators, and changemakers should have their own strong sense of, and believe deeply in, the relevance of math education. They should be able to see clear connections between that purpose and their daily experiences with learning and using math. In the face of a wide and diversifying array of approaches, platforms, and priorities for math education, defining a purpose that can endure in a changing landscape could anchor efforts to improve math education and help ensure that it serves the need of Black and Latino students and students from low-income backgrounds.

Tracking This Issue in the Possible Futures

Only in "Profit and Loss" does math education have a clear purpose within the public education system: It is designed to prepare people to participate in a high-tech economy. In the other three futures, math education has use in people's lives—to help communities meet their needs, to create community and peer connection, and to address social challenges—but its purpose is neither defined nor shared among constituents.

Applying This Issue to Your Context:

- What do the math education practices that you observe say about the current purpose of math education? Do they seem to promote economic mobility for learners? Social benefit for communities or society? Something else?

- How might conversations about relevance, rigor, and best practices in math education shift if they were aligned to a broader purpose for math education?

- How might greater definition of the purpose of math education improve instruction and outcomes for Black and Latino learners and learners from low-income backgrounds?

- What value might math have in the lives of people in ten or more years, including and beyond employment?

Issue Overview:

Mindsets about Technology

Technology and math education are linked in many ways.

Technology can be a powerful vehicle for learners to learn and apply math education; and the design and development of new technologies requires deep mathematical knowledge and skill. Both also warrant reflection on why and how they have been implemented in ways that have been shown to be harmful to young people, even when the intent had been to help and support them. Technology is often purported to connect people or to enable new models within and beyond education. Instead, it regularly sows disconnection and perpetuates oppressive models that cause harm, particularly to Black and Latino populations and people from low-income backgrounds.

Technology built primarily to maximize profit, productivity, or efficiency cannot be expected to lead to human connection, educational equity, or societal transformation. Nor can technology that is layered on top of inequitable and harmful educational systems and practices make fundamental differences in learners' experiences and educational outcomes. New underlying mindsets and development principles are needed for technology to have a role in supporting a version of math education that promotes relationships, agency, and creative thinking.

How and why technology might be used in the future of math education, and how effective it might be at engaging young people in meaningful math learning, will come down to the beliefs of the people developing and applying it and their resulting actions.

Tracking This Issue in the Possible Futures

In "Strengthening the Nodes" and "The Worlds We Build," educators and mentors of color are leading the way in reimagining the role of technology in society and education. Though tensions around the use of technology exist in these futures, those changemakers are attentive to its underlying design and purpose. Crucially, they are also aware of the impact of AI and virtual worlds on young people's ability to connect with others and with issues that matter to them. In "The Best Technology Is Us" and "Profit and Loss," ubiquitous technology is enmeshed in people's daily lives. It serves many useful purposes but also has unaddressed consequences as a result of having been implemented without thoughtful consideration of the mindsets and principles driving its development and adoption.

Applying This Issue to Your Context:

- In what ways might math education be structured to support all young people in becoming creators with technology and not merely consumers of it?

- How might mindsets around technological design and development need to shift so that technology can be a culturally relevant tool for human connection and help enhance human capacity? How could those mindset shifts improve math education for Black and Latino learners and learners from low-income backgrounds?

- How might insights about the ways in which biases, including racism and misogyny, are woven into today's technologies be applied in efforts to improve math education?

Issue Overview:

The Environment Surrounding Math Education

Math education is but one aspect of a much larger web of systems.

The ever-diminishing capacity of public education, as well as of public institutions generally, limits the extent to which math education might be improved meaningfully. Any shifts that might lead to improved math experiences and outcomes for Black and Latino students and for students from low-income backgrounds are inextricably linked with the rest of the educational system and with other systems outside of it.

The lack of access to high-quality educational resources, inequitable funding models, confining accountability and assessment systems, outdated approaches to teaching and learning, schools' lack of preparation for climate change and shifting demographics, and dehumanizing environments are not challenges specific to math education, but they affect any effort to change it. Treating math education as an isolated area perpetuates an environment in which critical issues—

such as education, climate change, and economic equity—are treated as competing priorities instead of linked challenges. Sustainable and widespread change in math education will require major shifts in other areas of society.

Tracking This Issue in the Possible Futures

Only in "Profit and Loss" is the public education system well-resourced, and that is simply because its purpose has been defined by business and industry. In the other futures, individuals are doing what they can in challenging circumstances; in many cases, they are pursuing meaningful math education. But they are not adequately supported, and their innovation comes at personal cost. It cannot lead to systemic transformation because there is not widespread commitment to making change across education and the other systems that influence it.

Applying This Issue to Your Context:

- How might public education, employers, community-based learning providers, climate changemakers, and other actors connect to improve overall community environments that could also help improve math education?

- What shifts or innovations in math education would enable positive shifts in other systems that influence the lives of Black and Latino students and students from low-income backgrounds?

- Recognizing the links between issues, what might be a starting point to create change? What first steps might lead to meaningful and intentional effects in other areas of the system?

Issue Overview:

Math Education as a Source of Healing and Support

Math education has been a source of trauma for many people, particularly for Black and Latino students and students from low-income backgrounds.

This systemic problem has created pain and shame. It can be observed in competitive math classrooms, in educators' biased assumptions about students' abilities, and in the divorcing of students' math experiences from their identities and emotional states. These experiences and the ways in which they shape people's beliefs about themselves and about math ripple through generations. Too often, educational change efforts focus on building resilience among individuals rather than addressing the conditions that caused harm in the first place.

Education, and math education specifically, can be designed as sources of healing and support. They can be intentionally oriented to foster well-being and to meet timeless human needs such as belonging, wonder, play, and the development of emotional intelligence. Academic subjects, particularly math, are often treated as being entirely separate from, and perhaps even in conflict with, social-emotional learning and support. They

could be treated as traversing intertwined paths, with math serving as an avenue that helps people connect with their identities and communities and with social-emotional learning serving as a necessary condition for rigorous skill-building. Trauma-informed math education could offer environments for healing and flourishing and could support belonging instead of othering.

Tracking This Issue in the Possible Futures

None of the possible futures portrayed in this forecast depicts healing math environments in an intentional and widespread way. In "The Worlds We Build," educators have some opportunities to create culturally relevant environments that enable young people to build connection to their identities, to one another, and to meaningful learning. Math is a critical element, but not the only focus of, these learning environments. Nonetheless, political polarization limits how widespread they can become. Each of the other futures depicts an educator or mentor seeking to make math meaningful and affirming to young people, but they are mainly left to solve that problem on their own.

Applying This Issue to Your Context:

- What math education practices that lead to harm and pain for young people do you see as being the most widespread or impactful?

- What opportunities might exist to eliminate those harmful math education practices, particularly those that most deeply affect Black and Latino students and students from low-income backgrounds?

- What connections among math, identity, social-emotional learning, and belonging currently exist in your context? Where could those connections be strengthened?

Conclusion
Strength in Numbers

Math education is deeply connected to other social, political, environmental, and economic factors. By exploring possible futures with this broad landscape in mind, we can begin to consider how best to build better futures for math education and for the people who will experience it.

Many Black and Latino students and students from low-income backgrounds manage to thrive today despite the discrimination and bias that haunt them. As we look to the future, it is our responsibility to create approaches to math education that support them by design.

Equipping ourselves, our organizations, and others with future-oriented, evidence-based knowledge about the future landscape in which math education could exist is the first step in making significant change. Informed by that broad perspective, we can apply that foresight to our efforts to realize a shared vision of what we want the future of math education to be for every student.

> Read more about recommendations for pursuing a shared vision for a liberatory future of math education in the companion piece, *Modernizing Math: Envisioning Liberatory Math Futures* by Optimistic Design.

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