Plenary Panel 2

Mathematics Education Reform post 2020: Conversations towards Building Back better

Mellony Graven[1], Marcelo Borba[2], Eva Jablonka[3],
Danny Bernard Martin[4] and K. (Ravi) Subramaniam[5]

ABSTRACT Our plenary panel focused on issues of mathematics education reform that have gained increasing significance since the start of the pandemic in 2020. Our panelists contributions provoked conversation about directions for mathematics education reform post 2020 with a view towards building towards 'better' quality and equitable mathematics teaching and learning for the future. Our topic cohered well with the 2021 International Day of Mathematics theme which was "Mathematics for a Better World". The panel engaged with equity issues relating to two interrelated aspects of 'building back better' as we emerge from the crippling challenges of the pandemic. The first issue related to transitions towards remote and online teaching and learning in mathematics education which gained speed due to the massive closure of, and disruption to, schools due to Covid across the globe. The second related to the 2015 United Nations Sustainable Development Goals (SDGs), aimed at building 'a better future'. We shared insights into emerging issues and research from across the globe and raised questions about the role of mathematics education in providing a better footing to achieve the SDGs and so build towards a more equitable future and a better world. Our paper is based on our panel contributions with voices and perspectives from diverse geographical backgrounds, research interests and expertise. The aim of the paper is to further provoke conversation about emerging and increasingly urgent issues our mathematics education community must grapple with.

Keywords: Reform; Equity; Sustainable development goals; On-line learning; Build back better.

[1]Faculty of Education, Rhodes University, Makhanda, Eastern Cape, 6140, South Africa. E-mail: m.graven@ru.ac.za

[2] Mathematics Department, São Paulo State University (UNESP), Rio Claro, São Paulo, 13506-900, Brazil. E-mail: marcelo.c.borba@unesp.br

[3] Department of Education and Psychology, Freie Universität Berlin, Berlin, 12049, Germany. E-mail: eva.jablonka@fu-berlin.de

[4] Department of Mathematics, Statistics, and Computer Science, University of Illinois at Chicago, Chicago, Illinois, 60607, USA. E-mail: dbmartin@uic.edu m

[5] The Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research Mumbai, Maharashtra, 400088, India. E-mail: subra@hbcse.tifr.res.in

1. Introduction. Panel Chair: Mellony Graven

In 2020 education systems across the globe faced major challenges in finding ways to enable continued teaching and learning in the context of a global pandemic that challenged opportunities for face-to-face classroom-based learning. In our panel, with the brief of focusing on key emergent mathematics education reform issues needing attention for 'building back better' in this post 2020 period, we identified two key issues to focus and frame our panel discussion. The first issue relates to transitions towards remote and online teaching and learning in mathematics education. This transition has recently gained speed due to the massive closure of, and disruption to, schools due to Covid across the globe. While online learning opportunities bring the possibility for increased access to quality mathematics education resources there is enormous uneveness in systemic and individual preparedness to optimise these opportunities. This plays out across countries and within countries and there is concern that the digital divide could exacerbate inequities across gender/social-class/race. Recent research evidence points to this concern playing out in real time across our home countries and the globe (Oxfam India, 2021; Borba, 2021; Martin, 2021; Jablonka and Bergsten, 2021; Vale and Graven, 2021). The second relates to the United Nations Sustainable Development Goals which were established in 2015 and aim to 'build a better future' by 2030 (UN General Assembly, 2015). While most countries are signatories on the SDGs, of which the fourth focuses on quality education for all, five years on these goals are far behind in meeting these targets. The SDGs include, for example, goals such as: no poverty; zero hunger; good health and well-being; quality education; gender equality; reduced inequalities; climate action; and peace, justice and strong institutions (among others). Covid is noted to have exacerbated challenges to progress in these goals yet some argue that emerging from the pandemic provides an opportunity for using the SDGs as a 'roadmap' to 'building back better'.

The phrase 'Build Back Better' initially emerged in the context of the Sri Lankan 2004 tsunami recovery efforts with the phrase looking to capture a comprehensive approach to recovery in which building back would not recreate or exacerbate existing vulnerabilities (Khasalamwa, 2009). The phrase was taken up in the UN conference on Disaster risk reduction in 2015 (UNISDR, 2015), in the same year the SDGs were adopted. In 2020 the world became increasingly aware of other 'disasters' beyond the pandemic. Some of this increasing visibility is a result of increasing access to digital news and social media. For example, the increasing exposure of extreme systemic racial inequality gave rise to the Black Lives Matter movement that began in the United States and gained momentum across the globe. 2020 and 2021 witnessed several climate related 'natural' disasters that disproportionately impacted those with fewer resources. The increasing proliferation of fake news highlighted the urgent need for people to be able to make informed decisions about how to respond to the many disasters (health, social, political, climate, economic challenges etc.) confronting their lives. While many mathematics educators have long argued the urgency of this need, 2020 was a pivotal year in placing a spotlight on the consequences of the failure of

education in general, and mathematics education in particular, in preparing learners for critical citizenship.

In the following sections our panelists focus on raising questions about how mathematics education should respond to a range of issues in the context of the rapid transitions towards remote and online teaching and learning and supporting the SDGs. We acknowledge that these are not the only issues needing urgent grappling post 2020, but we considered these important, timely, and of global relevance for providing foci for our panel.

2. What Is the Role of Media and Things in Mathematics Education Post-2020? *Panelist: Marcelo C. Borba*

The goal of my panel input was to show how the role of media and things in mathematics education. Ideas presented below can be found in a more profound way in Borba (2021), Engelbrecht et al (2020a, 2020b) and Borba, Souto e Canedo Jr. (2022) for those that Portuguese is easier to understand than English. Artefacts have always had a role in the development of mathematics, whether we talk about writing in paper, writing in tablets in Mesopotamia, the use of compass in geometry and more recently the use of digital technology (Villarreal and Borba, 2010). In the last decades different governments have tried to implement different programs to increase the use of digital technology in (mathematics) education. However, none of these programs, when we consider countries such as Brazil, have been as effective as the pandemic in stimulating the move to digital technology, illustrating the agency of the virus SarsCov-2. Questions worth asking are: Is this true in your country? If so to what extent and how has the pandemic influenced the move towards digital technologies for mathematical learning? What are some of the consequences of this for learners, teachers, the nature of mathematics taught and the pedagogies of teaching mathematics?

Reducing inequality is one of the goals for sustainable development, a major theme of this panel. Social inequality and economic disparities are a problem around the world. The pandemic has brought the need to incorporate digital technology in mathematics education, but teachers in schools in Brazil, and I expect elsewhere, had widely differing levels of readiness for their use of digital technologies – and these unequal levels or readiness link with societal inequalities of socio-economic status.

In the references mentioned above the notion of domestication of media was developed. Domestication means using a new media without exploring its potential, using it with rules and practices of an older media. In the case of Brazil, a clear example of this is that, many textbooks were just copied and transferred to digital media in the emergency remote teaching response. Many teachers, understandably, were teaching online "in the same way", with practices from regular classroom dominating. In this respect, most teachers, students and parents were not taking advantage of the emergence of a new medium. Instead, they simply reproduced existing teaching practices and text resources. So for example, teachers used the internet to simply record their usual chalk on board regular class instruction, followed by provision of standard

school practice exercises for learners to do at home (as they would in the class). However, there were others using PowerPoint, and the camera for recording images of key ideas or representations to share with learners, and thus it is possible to think of a rainbow of domestication of digital media.

In the papers by Borba and colleagues mentioned above it is argued that teachers could (and should wherever possible) be using animation in pieces of software such as GeoGebra to do dynamic mathematics. This then would allow one to explain to a much larger public, for example, that the sigmoid is important to model the way that the pandemic is unfolding. So, at a secondary school and beyond level, teachers could teach students about the sigmoid, its derivative, and how different sigmoids, lead to different peaks of the derivative. The notion of flattening the curve then may be understood by many more citizens and in more complex ways than simply 'seeing' the shape of the curve. An illustration of the sigmoid and its derivative can be visualized at this link https://igce.rc.unesp.br/#!/pesquisa/gpimem---pesq-em-informatica-outras-midias-e-educacao-matematica/animacoes/curva-epidemica-no-geogebra/. For each red curve (sigmoid) a different peak of the derivative, the rate of change curve, that can put the health system of a given community under stress can be seen.

In all the media presentations there is little discussion of why is it important to flatten the curve? Understanding mathematically the meaning of flattening the curve and how this connects with saving lives and allowing health systems to cope with cases is important. Saving lives can be demonstrated mathematically but students need to be able to access the mathematical meaning. I have argued with my students and shown them that the sigmoid in its derivative is true of exponential functions. In this way mathematics around exponential function may become meaningful in concrete rather than only abstract ways. Similarly, exponential functions are also important to understand social inequality to understand that the rich are getting exponentially richer and the poor are getting exponentially poorer and that the social disparity is growing exponentially. During the pandemic, the large multi-national companies that dominate the lives of many (and many more in these recent pandemic times), such as Facebook, Amazon and Google made their owners exponentially richer at the same time that populations in general were becoming exponentially poorer with many more people slipping into poverty. Therefore, it might be important to teach children how to count 1-2-3-4-5-6 but also 1-2-4-8-16-32-64… and backwards 64-32-16-8....

The use of technology in mathematics education can help with the tasks mentioned above whether we use concrete material, paper and pencil and/or digital technology. Digital technology, as other types of technology, can reduce or can increase inequality. Knowledge is seen as a product of collectives of humans-with-media. Different humans, different media (orality, writing, computing, for example) different knowledge, different ways of attaching meaning. Humans-with-Geogebra in the mathematics shown in the link above is a product of humans-with-media and once it is used in someone's formal or informal teaching, the animation presented in the link is part of such a collective.

In the pandemic another non-human-actor became very prominent in a collective that constructs mathematical knowledge. The agency of the corona virus resulted in emergency remote mathematics teaching. This meant children and young adults at home became important agents in their own and their families mathematics education. Quality of the home, availability of rooms for studying, internet connection and possibility of parents, other adults or older siblings in the home as helpers and facilitators of learning became paramount for mathematics education. This was irrespective of whether technology was used in a domesticated way or not.

Collectives of humans-with-media-homes exposed the increasing social inequality compared to those without. One cannot have education for all, or thinking about "building back better" without simultaneously addressing such social inequality and inequality in access to digital technologies and learning opportunities. We must face and eradicate social inequality to open the door to mathematics education to all. We must struggle to promote change in pervasive societal and economic inequality that gives rise to extreme differences in access to digital resources, access and learning opportunities to make mathematics education for all a possibility.

Different cell phones, different video, different connection influence different knowledge construction. We cannot have extreme social difference and simultaneously have equal opportunities for mathematics education. Schools may have shadowed the differences in home, as the picture in Borba (2021) shows. The capital to have different home and the new cultural capital - that includes not only the education of the parents and the parents and the community but also includes now the quality of the internet and homes - make mathematics education different for different students. If we are back to schools, we should never be able to forget the difference of schools itself depending on the neighborhood but also on the difference of homes. These differences the corona virus has made even more visible to us.

We have used more and more videos in mathematics education during the pandemic. Mathematics videos cannot hide social issues of homes and neighborhood. With the use of subtitles you may see a sample of videos produced by students-teachers-with-mobile-phones (https://www.festivalvideomat.com/). Digital technology can contribute to make visible what may be invisible for students: different social realities of their peers. So yes, while everyone needs clean water and functioning services in today's world they also need internet and homes that enable effective use of digital resources to be part of our collective of humans with media and things!

I end with drawing on Paulo Freire, a Brazilian educator. He has said If education alone does not transform society, neither does society change without education? We can paraphrase such a sentence! Without mathematics education for all, without understanding of exponential functions linked to the mathematics of the pandemic, can we overcome inequality? Can a collective of students and teachers with media be prepared for the next pandemic?

3. The Use of Mathematics in Communicating an Urgent Need for Action and Questions for Education. *Panelist: Eva Jablonka*

3.1. Mathematics in contexts of crises

In approaching the theme of the panel on the ground of my expertise I shall focus on the role of mathematics in communicating an urgent need for action. It has been emphasised that mathematics education should address the public use of numbers, quantities, metrics or indicators – henceforth all denoted as 'numbers' (e.g., Fischer, 1993; Jablonka, 2003; Dowling 2009, Chronaki, 2017). In contexts of crises numbers are often used (i) to communicate the 'reality' behind something that happens, of which we see only some symptoms, (ii) to project what will continue to happen if no action is taken, and (iii) to predict what would happen if particular actions were taken.

Before proceeding to examine the public use of numbers, I would like to look at a fictitious situation of crisis in the story of an epidemic in a quarantined city: In the beginning of the epidemic, when regular broadcasting of the official statistics started, "[…] the reaction of the public was slower than might have been expected. Thus, the bare statement that three hundred and two deaths had taken place in the third week of plague failed to strike their imagination." Subsequently, "[…] a new phase of the epidemic was ushered in when the radio announced no longer weekly totals, but […] deaths in a day." When observing this practice, the fictitious chronicler comments, "The newspapers and the authorities are playing ball with the plague. They fancy they're scoring off it […]." (Camus, 1991/1947, p. 113)

Numbers still do not strike audiences' imagination but listening to numbers via radio has become rare in 2021. The ubiquity of screens on TV, computers and mobile devices clearly has increased engagement with the visual; black-boxed mathematics in the form of visualisations of complex data and interactive tools are designed to inform non-experts (with stark differences in the quality between the so called "prestigious" and "popular" media). There has been an intensification in the use of mathematical models and speedy computations with massive data and an extended use of experts in political decision making (whose role is contingent upon the type of political system). There is a need to examine the implications for mathematics education.

3.2. An example of numbers in public discourse in Germany

The public discourse in Germany during the first epidemic wave of COVID-19 in 2020 is a useful example. Numbers featured prominently in the (changing) construction of what constitutes the crisis and in communicating an urgent need for action. The numbers were generated in a range of academic fields, such as epidemiology, infectiology, virology, demography and public health care resource statistics. Numbers included: cases, new cases, person-time incidence rate, deaths, case fatality rate, excess mortality, recovered, doubling time and effective reproduction number. In a systematic study we identified different strategies of using these numbers to defend the regulations directed to contain the spread of the virus (cf. Jablonka and Bergsten, 2021):

Rationalisation: This is the strategy one expects in a rational policy discourse that relies on experts from academic fields. It consists in the use of numbers in factual statements for providing evidence as well as in arguments and explanations, that is, elements of scientific discourse from the relevant fields. A residual strategy of rationalisation creates the impression of fact, probability and verisimilitude by means of mere repetition and compilation of numbers.

Contrast: This strategy of using numbers consists in establishing a stark contrast between numbers qualified as "high" and others described as "low", and at the same time invoking emotions on one side of the comparison, as, for example, a looming menace associated with "high" numbers. This strategy is highly adaptable in terms of supporting or opposing a particular need for action, as both the context of comparison and the selected numbers can be chosen accordingly.

Association: This strategy also appeals to imagination and fantasy, but here numbers are not compared across or within contexts; instead, particular numbers are selected and then combined with representations of concrete events, objects or behaviours seen as equivalent with overcoming the crisis or hindering this. For example, some metrics were combined with images of clubbing young people to create the association that their behaviour is responsible for "high" numbers.

Recharging: This strategy consists in presenting concrete examples of first-hand experiences, personal narratives, testimonies or individual fates "behind" the numbers. Thereby the numbers become recharged with subjectivity and materiality that have been stripped off through the mathematisation. It can be interpreted as a move towards overcoming the effect of "ethical filtration" (Skovsmose, 2006) resulting from the transformation of the handling of a complex situation into a technical problem by which moral considerations or ethical dilemmas apparently are cleared away.

These strategies of overcoming the apparent neutrality of depicting the problem by means of numbers (the kernel of rationalisation) appeared as an integral element of the public policy discourse. The discourse also included the daily presentation and production of numbers on liveblogs, infographics and interactive maps. In addition, there appeared some black-boxed mathematics, such as simulators for different epidemic scenarios or interactive tools for calculating the individual risk of infection in different environments; these fool the user into believing to be in a position of attaining definitive solutions to complex problems (cf. Gellert and Jablonka, 2009).

3.3. Examples from other contexts

Similar use of numbers that emanate into public discourse from mathematical models or simulations produced in diverse academic fields are particularly found in policy fields that relate to the United Nations Sustainable Development Goals. These often rely on complex data that can only be communicated via sophisticated visualisations designed for non-expert audiences. Space does not permit more than two examples.

The example from the German Aerospace Center (DLR) is a good illustration of a visualisation (Fig. 1) of complex data used for providing evidence (rationalisation). It

relates to DLR's programme theme "earth observation" tailored "to the current and future scientific, societal, political and economic challenges posed by global processes and changes" (DLR, n.d). It shows the reduction in air pollution as an outcome of lockdown measures in 2020. Data have been adjusted for effects due to weather; one still can "see" the positive effect on air quality through comparing the images.

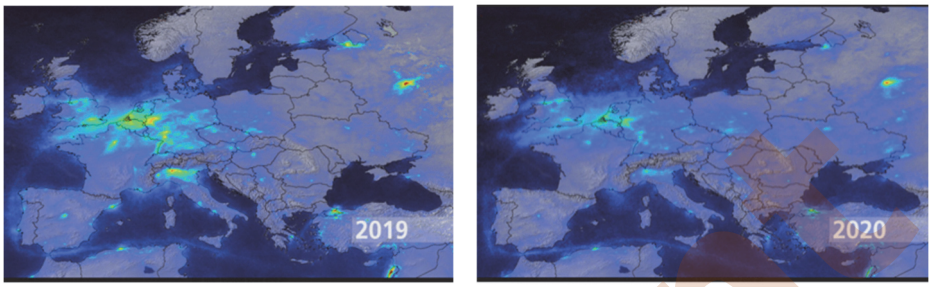

Fig. 1. DLR (2020, May 5). Comparison of nitrogen dioxide emissions over Europe between March/April 2019 and 2020, image 1(4).
Credit: DLR (CC BY-NC-ND 3.0)

The second example illustrates the use of numbers in strategies that involve appeal to affect, emotion or fantasy. In the yearly reports "Global Trends" of the United Nation's Refugee Agency with statistics on forced displacement of people that aim at enhancing public understanding, the strategy of recharging is commonly used. The reports regularly include photographs and short descriptions of individual fates. Examples in the latest report (UNHCR, 2021) include the fate of a Syrian refugee and his grandson (p. 13), an internally displaced woman in Kongoussi (p. 23); displaced people in canoes on flood water around Pibor (p. 26); the internally displaced young footballer Maria Romanchenko in Odessa (p. 28); an asylum-seeking family who fled from Honduras to Guatemala (p. 31); asylum-seekers in Congo Rive village (p. 37).

3.4. Questions for mathematics education

To summarise, in many public reports of supranational institutions, non-governmental organisations and local campaigns of policy actors who communicate the urgency of some political action we find black-boxed mathematics in form of sophisticated visualisations and strategies of communication similar to those found in the context of the pandemic. These are necessary when the data are too complex and also because numbers never speak for themselves. How should the use of numbers in communicating political priorities enter mathematics education?
Resulting from this unavoidably incomplete and inconclusive sketch of various issues related to the use of numbers, I would like to propose three questions to be asked in mathematics education as research and as practice:

(1) Where is the space in the curriculum for dealing with black-boxed mathematics in the form of visualisations?

(2) If more locally relevant topics related to Sustainable Development Goals are to be included in the teaching of mathematical modelling and statistics, how can a balance be found between simplifying the socio-political complexity of the problems and focusing on mathematically important issues?

(3) Shall mathematics still be taught as neutral tool and mathematics educators try to avoid appealing to affect, emotion and fantasy or shall it include discussions of strategies and the art of using numbers for getting a political message across?

4. Is the Future of Mathematics Education Black? *Panelist: Danny Bernard Martin*

4.1. Motivational context

My decision to frame the future of mathematics education in the United States around the question in the title of this paper is partially shaped by my positionality as a Black man in America. In this country, I belong to a group whose bottom-level status in the social hierarchy has been fortified in law, policy, practice, and reform for more than 400 years. Recurring instances of extrajudicial killings of Black people by police, the disproportionate effects of COVID-19, and efforts to disenfranchise Black voters across America serve as visible reminders of this bottom-level status. While many people across the globe may have been shocked by the recent killings of Black people by American police, or by the disproportionate impact of Covid-19 on Black people, the year 2020 was in many respects completely normal for Black people. It was not an aberration. Going back 10, 20, or even 100 years would reveal similar outcomes in many different areas of Black life.

Therefore, my thoughts about the future of mathematics education cannot ignore the realities of the past and present, and they cannot be confined to issues of teaching, learning, curriculum, and assessment. Against the backdrop of these observations, let me say a bit more about the question, Is the future of mathematics education Black? I claim that: there is no future for mathematics education in the United States if a reimagined (not reformed) mathematics education does not value the lives and humanity of Black people, contribute to their collective liberation and flourishing, and stand in opposition to white supremacy, antiblackness, and racial capitalism. if not, the future of mathematics education will continue to reflect the present and the past.

4.2. White supremacy, antiblackness, and racial capitalism

In America, the past and present reflect the fact that despite decades of curriculum and teaching reform, many Black children continue to experience dehumanizing and violent forms of mathematics education. These dehumanizing and violent experiences are rooted in systems of white supremacy, antiblackness, and racial capitalism. Invoking white supremacy, antiblackness, and racial capitalism should not be viewed as unnecessary provocation. Historical analysis shows that they are foundational to the birth of America, and they continue to undergird almost every American institution. In

many ways, white supremacy is the thread that holds America together, stitching together the past, the present, and the future. Invoking antiblackness provides the necessary language to explain the particularities of Black oppression, and the willingness of American institutions to dehumanize Black people and inflict gratuitous violence. Racial capitalism helps to explain how Black pain, Black suffering, and fabrications of Black pathology continue to serve as commodities for capital accumulation. During chattel slavery, for example, the bodies of Black people were considered property and their free labor generated much of America's wealth. More than one hundred fifty years later, the marginalization of Black people in mathematics has resulted in a proliferation of 'intervention economies' focused on fixing Black learners and increasing their achievement and participation in mathematics (Martin, 2021).

The persistence of Black racial oppression in America over the past 400 years serves as a reminder that white supremacy is a self-correcting system that has resisted every attempt to dismantle it. As noted by the writer Ta'Nehisi Coates (2014), "white supremacy is… a force so fundamental to America that it is difficult to imagine the country without it. And so, we must imagine a new country." In my opinion if America cannot be reformed away from white supremacy, then the same is true for mathematics education. I can modify the Ta'Nehisi Coates from earlier to say: white supremacy is … a force so fundamental to [mathematics education] in America that it is difficult to imagine [mathematics education] without it. And so, we must imagine a new [mathematics education].

4.3. Myth of Black inclusion

Confronting the realities of white supremacy, antiblackness, and racial capitalism in mathematics education also means confronting the myths and realities of Black inclusion and the myths that are perpetuated about reform. Recent data show that after steady increases from the late 1980s to the early 1990s, the percentage of Black mathematics majors has decreased during the past 25 years and stabilized to around 5% (Bressoud, 2018). This time frame coincides with several mathematics education reforms in the United States, with many of these reforms focused on diversity and inclusion (Martin, 2019). Over the same time frame, the number of Black mathematics majors at US universities, represented by the blue curve, has remained relatively flat (Bressoud, 2018). Across these contexts, at least, Black inclusion into mathematics is a myth.

My own research and the work of several colleagues has documented other realities and material consequences of white supremacy, antiblackness, and racial capitalism for Black learners in mathematics education (Martin, 2013, 2019; Davis and Jett, 2019). In very recent work, colleagues and I discuss how Black learners encounter and negotiate various forms of violence, including epistemological, violence, systemic violence, and symbolic violence (Martin, Price, and Moore, 2019). For example, we show how knowledge production often reifies the idea of Black inferiority in

mathematics by using statistics as a proxy for truth. Drawing on the work of Thomas Teo (2010), we frame this as epistemological violence. We also show how school-based mathematical practices limit Black students' access to identities as creators and doers of mathematics, reserving these identities for white and Asian learners. We link these practices to symbolic violence.

Consider recent research by Faulkner et. al. (2014). Using data from the Early Childhood Longitudinal Study–Kindergarten Class of 1998-1999 (ECLS-K) data set, they analyzed the mathematics placement profiles of Black students and White students from late elementary school through 8th grade. In particular, the authors analyzed the impact of teacher evaluation of student performance versus student demonstrated performance on the odds of being placed into algebra in the 8th grade. Please note that in the United States, Algebra serves as an important gateway and gatekeeper course to more advanced mathematics and other prized educational opportunities. Results of the study revealed that Black students had reduced odds of being placed in algebra by the time they entered 8th grade even after controlling for performance in mathematics. The odds of placement in algebra by the eighth grade for Black students were reduced by two-thirds to two-fifths compared to their White peers. The authors concluded:

> Black students confront an untenable impediment in that their Blackness (or, as we suggest here, the teachers' implicit responses to these students' Blackness) … is an invisible… obstacle to gaining access to higher level mathematics courses, irrespective of their demonstrated performance.

In other words, meeting and exceeding standards are not enough counterbalances to antiblackness and white supremacy. Let me be clear that I am not making an argument for inclusion. If inclusion means inclusion into a system that is fundamentally anti-Black, I cannot support that. Building back better must mean more than inclusion into mathematics as it is. Rather, the focus should be on building a humane, anti-racist mathematics education free of white supremacy, antiblackness, and racial capitalism.

4.4. Racial projects and mathematics education

Why has mathematics education in the United States not stood in opposition to white supremacy, antiblackness, and racial capitalism? Let me make another claim: mathematics education reforms in the United States have always been aligned with political projects promoting white supremacy, antiblackness, and racial capitalism (along with nationalism, xenophobia, militarism, neoliberalism, etc.).

What evidence do we have for this claim? In a recent paper (Martin, 2019), I discuss how various math education reform movements in the United States have co-evolved with the prevailing political and racial projects in the larger society. For example, the new math reforms of the 1950s and 1960s unfolded while America was maintaining legalized segregation. Those new math reforms were not intended for

Black Americans, and there is no historical evidence that mathematics education stood in opposition to white supremacy, antiblackness, and racial capitalism. Thirty years later, beginning in the 1980s, mathematics education was enlisted to support Reagan-Clinton-era neoliberalism and Bush-era neoconservatism focused on national security and social welfare reform. Currently, U.S. mathematics education is in the Common Core reform era and America finds itself entangled in the racial politics that led to the election of Donald Trump, the Black Lives Matter movement, COVID, white supremacist insurrection, and the transition to the Biden presidency.

Given the ongoing entanglement of racial and political projects with the project of mathematics education, what is the future of mathematics education? Rather than asking, Is the future of mathematics education Black? I suggest that the future of mathematics education in the United States must be Black. Mathematics education in the United States has no future if it does not value the lives and humanity of Black people and contribute to their collective liberation and flourishing. There must be an agenda to build Black futures and forms of mathematics education that stand in opposition to white supremacy, antiblackness, and racial capitalism.

4.5. Beyond the United States: Race and mathematics education in global contexts

Before closing this paper, I want to acknowledge that the realities of white supremacy, antiblackness, and racial capitalism in America do not map neatly onto other locations around the globe, even in those contexts where race is socially and politically significant such as South Africa and Brazil. The meanings, processes, and material consequences of race and racism are different in these three contexts. However, white supremacy, antiblackness, and racial capitalism are still very salient in all three contexts. Let me also be clear that even in those contexts where it is believed that race is not an issue because 'we have no Black people here,' critical questions can, and should, be raised. What are the implications of the existence of a far-right, conservative racial project for mathematics education in Denmark and for immigrant families and their children? How do experiences with everyday racism by Malays and Indians in Singapore, groups who occupy very different positions in the social hierarchy, play out in the context of mathematics education? How do the manifestations of caste shape mathematics education in India? What are the racialized conditions of mathematics education for Indigenous people of Australia (post White Australia policy) or the Māori in New Zealand?

5. Can Mathematics Education Help Reduce Inequality? *Panelist: K. Subramaniam*

The pandemic has caused a disruption of scholarly work and exchange that is only a shadow of the devastation it has caused in the lives of the less privileged. I will use the occasion not so much to look back on my previous work, but to interrupt it with questions that our collective experience of this disruption throws up. The question that

I focus on is “Can mathematics education help reduce inequality?”. At the back of my mind is the question “What conversations do we as mathematics educators currently prioritize what conversations do we need to prioritize?” One of the sustainable development goals, SDG 10, is to reduce inequalities. The pandemic has sharpened the inequality across the world. Countries like India with deeply entrenched inequality are particularly hard hit. About 90% of the Indian workforce is in the informal economy. Many millions of Indian workers lost their jobs when the pandemic related lockdown was imposed and had to walk hundreds of kilometres to return to their home states. About 400 million Indians risk falling deeper into poverty due to the lockdown imposed in the wake of the pandemic (Oxfam India, 2021). In shocking contrast, in the period of the disaster, the wealthiest in the world leap frogged into even greater wealth. During the pandemic, the top ten billionaires in the world increased their wealth by nearly 50% over ten months (Oxfam India, 2021). In India, the top billionaires increased their wealth by 80%. Some increased their wealth multiple fold, even in comparison to their wealth before the pandemic began. Our political economic arrangements ensure that this huge suddenly acquired wealth for a rich minority bring no relief at all to those who have been impoverished by the disaster. Wealth tax is taboo and the preferred route by governments is to increase the tax on fuel further burdening those at the bottom of the pyramid. My co-panelists have already spoken about educational and social inequality. Clearly inequality, whether economic or social, will not really be overcome without democratic political struggle by those who are marginalized.

The period of the pandemic has also seen large scale protests in several countries. For example, the Black Lives Matter movement in the US, the farmers’ movement in India, the movement to restore democracy in Myanmar, and other movements in several countries. Most of these movements were not related to the pandemic, but they were thrown into relief because of the extraordinary times we were living through. They served as a reminder that political movements are great opportunities for education, indeed they are opportunities for us educators to be educated. We forget easily that such movements can be occasions for mass education. How can we restore the connection between social movements and the education curriculum? What does this mean for mathematics education? In India, hundreds of thousands of protesting farmers demanded the repeal of laws that were thought to favor corporates and put farmers’ futures at risk. The movement shone the torch not only on issues related to farm income, but also on issues like ecological degradation, and the control of the public discourse by media manipulation. These are important issues for education that is aimed at transforming society.

In developing countries with widespread inequality and poverty, the agenda of social transformation becomes one of the primary aims of education. Ambedkar, who came from the oppressed Dalit caste and is regarded as the architect of the modern Indian constitution, emphasized the role of education in emancipation from caste oppression: “Coming as I do from the lowest order of the Hindu society, I know what is the value of education. The problem of raising the lower order is deemed to be

economic. This is a great mistake…. The problem of the lower order is… to create in them [a] consciousness of the significance of their lives for themselves, and for the country, of which they have been cruelly robbed by the existing social order" (Quoted in Velaskar, 2012).

Education, as Ambedkar says, has a great role in social transformation. But what about mathematics education? How can mathematics education help meet the goal of reducing inequality and of social transformation? Of course, mathematics opens up the pathways to highly valued jobs. To break out of the rigid occupational structures is an important aspect of social transformation and mathematics education can create pathways for such occupational mobility. Ambedkar emphasized not only material gain from education, but also gaining self-respect, and self-understanding. Critical mathematics education researchers from many different places have shown how mathematics can help sharpen our perception and understanding of inequality and the structures that underpin it (Gutstein, 2016; Rampal, 2015). However, in the existing curriculum in India and many countries, there is very little of mathematics that can illuminate social reality.

In the last round of major curriculum reform in India in 2005, efforts were made to introduce critical mathematical perspectives in the curriculum. For example, a "problem" from the Grade 5 textbook, discusses the wages paid to a couple who are farm labourers. It is mentioned that the legal minimum wage is 71 rupees per day. However, the man is only paid Rs 58 and the woman Rs 55 per day by the landlord. The problem asks students to find how much money the couple will earn for a certain number of days. More importantly for our purposes, there are two supplementary "discussion" questions in the problem. One points out that the landlord pays less than the minimum wage. Another points out that the woman is paid less than the man and asks students to discuss these observations. Firstly, even the inclusion of such questions that take a critical look at society in a mathematics textbook is remarkable and rare in the Indian context. Second, Shikha Takker found that teachers often omit discussion of such questions for various reasons (Takker, 2015). On one occasion, a teacher told Takker that she would like to focus on the mathematics and avoid the distraction that such questions entail. On another occasion, the teacher said that she did not feel equipped to deal with the discussion that might ensue if these questions were brought up. We can also imagine that there is resistance to raise questions with political undertones, which in certain situations may carry a risk for the teacher. But as mathematics education researchers, we need to ask if we can we continue to ignore these dimensions if we are serious about reducing inequality.

The mathematics involved in the examples discussed above about wealth and incomes is simple: at the most, finding and comparing percentages and ratios. Their application to understanding social reality can however be powerful. And even though the mathematics is simple, the socio economic and social political concepts involved may be sophisticated. Sometimes, the emphasis on "important mathematics", which is echoed in many curriculum reform efforts, can lead to giving less importance to the

applications of mathematics which can bring about a critical focus on social reality (Noronha and Soni, 2019).

Finally, let me summarize some questions that these reflections have given rise to. Do we need to revisit our notion of what constitutes mathematics to allow for socially meaningful questions to be raised? Why does the use of mathematics to understand social reality appear as a distraction? Do our notions of "powerful mathematics" conflict with powerful uses of mathematics? Why does our curriculum not make any connection to social movements? Finally, while the mathematics curriculum typically makes at least some connections with the science curriculum, why does it make so little connection with the social science curriculum?

6. Concluding Remarks. *Panel Chair: Mellony Graven*

The aim of this paper, emanating from our panel, is to continue to provoke conversation about critical issues in our current world that require urgent attention by mathematics educators. As panelists we are committed to contributing towards a more equitable world and grappling with the way in which mathematics education can contribute meaningfully to this goal.

Marcelo Borba raised the importance of placing the spotlight on the role of media ('and things') and the dangers that come with the domestication of media without maximizing the full potential of different media. Existing unequal access of different groups to increasingly essential media and technological devices need to be urgently addressed to avoid compounding inequalities. He shared a range of ways in which he and other colleagues have drawn on digital media and animations in ways that allow students to understand more deeply the emerging pandemic data (particularly exponential data) and the meaning of emerging phrases such as 'flattening the curve'. He urges mathematics educators to consider how we might prepare students and teachers with media for the next pandemic.

Eva Jablonka focused on the role mathematics plays in communicating the need for policy measures. She reveals different strategies used in public discourse to overcome the seeming neutrality of depicting with numbers and communicate the urgency for action. Since some black-boxed mathematics occurs to simplify complex data and is then used to communicate and sway public views and actions she argues that we need to ask how the use of numbers in communicating political priorities should be included in mathematics education, how we should manage simplification of socio-political complexity of problems and the mathematics involved and whether we should discuss the ways in which strategies push for action or continue to present the myth of mathematical neutrality.

Danny Martin drew on his work and experiences, positioned as a Black man in America, to argue that mathematics education cannot ignore the racist realities of the past and present that are endemic across institutions. He argues that there can be no future for mathematics education in the United States without a reimagined mathematics education that values the lives of Black people and opposes white

supremacy, antiblackness and racial capitalism. He distinguishes reimagined from reformed, drawing on research to show that reforms in mathematics education have themselves contributed to entrenching inequalities and injustices in opportunities for Black Americans. He emphasises this is not limited to the United States, arguing the myth of Black inclusion is relevant and important across first world and developing countries.

K. Subramaniam highlighted the pandemic as an opportunity to interrupt earlier assumptions about priorities in mathematics education and ask what must be prioritised now for reducing rapidly growing inequality. He notes that since the pandemic 400 million Indians are in deeper poverty while the top billionaires increased their wealth significantly (as did the top billionaires in the world). He reflects on the way in which 2005 curriculum reform in India highlighted developing a critical mathematics perspective and yet even in the few resources that include problems with data pointing to social injustices teachers tend to avoid such discussions. He argues that we cannot continue to ignore developing a critical perspective through engaging with mathematical and other data that highlights the need for prioritizing a more equitable society and world.

We hope this paper has stimulated thinking about how the issues raised relate to the contexts in which you are working. Our wish is that the questions we have asked will provoke further conversation and action in responding to the challenges to build a better future.

References

M. C. Borba (2021). The future of mathematics education since COVID-19: Humans-with-media or humans-with-non-living-things. *Educational Studies in Mathematics*, 108(1), 385–400.

M. C. Borba, D. L. P. Souto and N. R. Canedo Junior (2022). Vídeos na Educação Matemática: Paulo Freire e a quinta fase das tecnologias digitais. Autêntica

D. Bressoud (2018, May 1). *Trends in Mathematics Majors*. Launchings. Washington, DC: Mathematical Association of America.

T. N. Coates (2014, May). The case for reparations. *The Atlantic.*

A. Camus (1991/1947). *The Plague*. Translated from the French by Sturt Gilbert. New York: Vintage International, Random House.

Chronaki, A. (Ed.) (2017). Mathematics in Life and Times of Crisis: *Proceedings of the Ninth International Mathematics Education and Society (MES) Conference*. Volos, Greece: MES.

J. Davis and C. Jett, C (Eds.) (2019). *Critical Race Theory in Mathematics Education*. New York, NY: Routledge.

DLR German Aerospace Center (2020, May 5). News. Earth observation using satellites. Despite the influence of weather patterns, the effect of the Coronavirus on air quality is now visible. Deutsches Zentrum für Luft- und Raumfahrt. https://www.dlr.de/

content/en/articles/news/2020/02/20200505_effect-of-the-coronavirus-on-air-quality-is-now-visible.html

DLR German Aerospace Center (n.d). Earth observation. Deutsches Zentrum für Luft- und Raumfahrt. https://www.dlr.de/content/en/articles/space/earth-observation.html

P. C. Dowling (2009). *Sociology as Method: Departures from the Forensics of Culture, Text and Knowledge*. Rotterdam: Sense.

V. N. Faulkner, L. V. Stiff, P. L. Marshall, J. Nietfeld, and C. L. Crossland (2014). Race and teacher evaluations as predictors of algebra placement. *Journal for Research in Mathematics Education*, 45(3), 288–311.

J. Engelbrecht, M. C. Borba, S. Llinares, and G. Kaiser (2020). Will 2020 be remembered as the year in which education was changed? *ZDM*, 52(5), 821–824.

J. Engelbrecht, S. Llinares and M. C. Borba (2020). Transformation of the mathematics classroom with the internet. *ZDM*, 52(5), 825–841.

R. Fischer (1993). Mathematics and social change. In S. Restivo, J. P. van Bendegem and R. Fischer (Eds.), *Math Worlds: Philosophical and Social Studies of Mathematics and Mathematics Education*. Albany: State University of New York Press, pp. 197–219.

U. Gellert and E. Jablonka (2009). The dematheматising effect of technology: Calling for critical competence. In P. Ernest, B. Greer and B. Sriraman (Eds.), *Critical Issues in Mathematics Education*. Charlotte, NC: Information Age Publishing, pp. 19–24.

E. R. Gutstein (2016). "Our issues, our people — Math as our weapon": Critical mathematics in a Chicago neighborhood high school. *Journal for Research in Mathematics Education*, 47(5), 454–504.

E. Jablonka (2003). Mathematical literacy. In A. Bishop, M. A. Clements, C. Keitel, J. Kilpatrick and F. K. S. Leung (Eds.), *Second International Handbook of Mathematics Education*. Dordrecht: Kluwer Academic Publishers, pp. 77–104.

E. Jablonka and C. Bergsten (2021). Numbers don't speak for themselves: strategies of using numbers in public policy discourse. *Educational Studies in Mathematics*, 108, 579–596.

S. Khasalamwa (2009). Is 'build back better' a response to vulnerability? Analysis of the post-tsunami humanitarian interventions in Sri Lanka. *Norsk Geografisk Tidsskrift-Norwegian Journal of Geography*, 63(1), 73–88.

D. B. Martin (2021). Refusing capital accumulation and commodification: A brief commentary on mathematics identity research. In J. M. Langer-Osuna and N. Shah (Eds.), *Making Visible the Invisible: The Promise and Challenges of Identity Research in Mathematics Education.* Journal for Research in Mathematics Education Monograph Number 17. Reston, VA: National Council of Teachers of Mathematics, pp. 123–135.

D. B. Martin (2019). Equity, inclusion, and antiblackness in mathematics education. *Race Ethnicity and Education*, 22(4), 459–478.

D. B. Martin (2013). Race, racial projects, and mathematics education. *Journal for Research in Mathematics Education*, 44(1), 316–333.

D. B. Martin, P. Price and R. Moore (2019). Refusing systemic violence against Black children: Toward a Black liberatory mathematics education. In J. Davis and C. Jett (Eds.) *Critical Race Theory in Mathematics Education*. New York: Routledge, pp. 32–55.

A. Noronha and N. Soni (2019). Making sense of percentages and its importance in unpacking inequality and discrimination. In: J. Subramanian (Ed.). *Proceedings of the Tenth International Mathematics Education and Society Conference*. Hyderabad: MES10.

Oxfam India (2021) *The Inequality Virus: Davos India Supplement*. New Delhi: Oxfam India.

A. Rampal (2015). Curriculum and critical agency: Mediating everyday mathematics. In S. Mukhopadhyay and B. Greer (Eds.) *Proceedings of the Eighth International Mathematics Education and Society Conference*. Portland: MES-8, 83–110.

O. Skovsmose (2006). Challenges for mathematics education research. In J. Maaß and W. Schlöglmann (eds.), *New Mathematics Education Research and Practice*. Rotterdam: Sense Publishers, pp. 33–50.

S. Takker (2017). Challenges in dealing with social justice concerns in mathematics classrooms. In A. Chronaki (Ed.). *Proceedings of the Ninth International Mathematics Education and Society Conference*. Volos: MES-9, 936–945.

T. Teo (2010). What is epistemological violence in the empirical social sciences? *Social and Personality Psychology Compass* 4(5), 295–303.

UN General Assembly. Transforming our world: the 2030 agenda for sustainable development, 21 October 2015, A/RES/70/1. available at: https://www.refworld.org/docid/57b6e3e44.html [accessed 7 March 2022].

UNHCR United Nations High Commissioner for Refugees (2021). Global trends. Forced displacement in 2020. https://www.unhcr.org/flagship-reports/globaltrends/.

UNISDR (United Nations International Strategy for Disaster Reduction) (2015). Sendai framework for disaster risk reduction 2015–2030. http://www.wcdrr.org/uploads/Sendai_Framework_for_Disaster_Risk_Reduction_2015-2030.pdf. [accessed 7 March 2022].

P. Vale and M. H. Graven (2021). Reflecting on dilemmas in digital resource design as a response to COVID-19 for learners in under-resourced contexts. *Pythagoras*, 42(1), 17.

P. Velaskar (2012). Education for liberation: Ambedkar's thought and Dalit women's perspectives. *Contemporary Education Dialogue*, 9(2), 245–271.

M. E. Villarreal and M. C. Borba (2010). Collectives of humans-with-media in mathematics education: notebooks, blackboards, calculators, computers and… notebooks throughout 100 years of ICMI. *ZDM*, 42(1), 49–62.