Article

Volume 4 (2025), pp. 48-65
American Journal of STEM Education:
Issues and Perspectives

Challenging a Curriculum of Disembodiment: STEM Education in Two Canadian Classrooms

Tasha Ausman
University of Ottawa, Canada

Catherine James
University of Ottawa, Canada

ABSTRACT

We conceptualize the effects of the absence of cultural and historical narratives in science and mathematics as a phenomenon which distances the learner from the rich cultural and narrative histories in STEM subjects through a theoretical framework we call a curriculum of disembodiment. Using Bourdieu (1986) to understand the habitus that STEM students currently occupy, we contend that children are taught to strive for greater social and economic power through STEM learning designed for utilitarian purposes that garner them social and economic capital. Facing feelings of anxiety, disembodiment and trauma, many secondary students have a contentious or nearly absent relationship with our STEM courses. In response, we implemented culturally relevant teaching practices and assessments (Ladson-Billings, 1995). The results included higher student engagement and increased student voice.

Keywords: Culturally relevant pedagogy; disembodiment; habitus; history of mathematics and science

INTRODUCTION

Mathematics and science have been at the heart of progressing human civilizations for tens of thousands of years. The Ishango bone, discovered in what is now the Democratic Republic of Congo (dating between 18000BCE and 20000BCE) displays tally marks on it, attributed to an early lunar phase count or other arithmetic construction (Gerdes, 2008). The Sumerian and Babylonian systems of measurement in cuneiform script (3000BCE) involved using wedge-shaped characters in a sexagesimal system – combining 10 with a "celestial" 6, which enabled a base figure of 60 that allowed both Sumerians and Babylonians to undertake fractional division, multiply in the millions, measure square roots, and perform exponent calculations (Joran, 2007). For millennia, Indigenous Alawa, MalakMalak, and Jawoyn peoples of Northern Australia have tracked kites' and falcons' use of tools – specifically, burning sticks – used by the birds to spread fire and make available fleeing rodents and insects. And in British Columbia, "[o]ver the course of thousands of years, the ancestors of the Kwakwaka'wakw and other Indigenous groups there created and maintained what have become known as "clam gardens"—rock-walled, terrace-like constructions that provide ideal habit for butter clams and other edible shellfish" as a form of sustainable mariculture called *loxiwey* (Nicholas, 2018, para. 11). While these facts are fascinating, one might ask: what do examples of pre-Greek mathematics and science have to do with modern conventions of STEM schooling in Canada and why do they even matter?

As classroom teachers in science and mathematics, we reflect on the absence of accurate narrative origins of the subjects we teach – and were taught in our own schooling. Our secondary mathematics classes in the USA and Canada in the 1980s and 1990s reproduced the common mythology that the origin of a cohesive set of principles belonged solely to the Greeks. Moreover, presented as a neutral subject, mathematical instruction further erased even Greek historical contributions, with the singular exception of the inaccurately named Pythagorean Theorem (it is well known that trigonometry was used 1000 years prior by the Babylonians). In our science learning, principles originated with the scientific method and the rise of Enlightenment thinking during the "Age of Reason," leading onward to the achievements of Newton, Galileo, Avogadro, Darwin and others through the centuries. Even obvious contributions by ancient Egyptians such as the pyramids at Giza, or Polynesians who built the *moai* statues of Rapa Nui (Easter Island) were relegated to middle school history classes as features of a past culture, not the feats of engineering and mathematics that deserve a place in STEM courses. This is particularly ironic in the latter case of the *moai*, as the statues were carved between 1100 and 1650AD, concurrent to the development of European technologies following the Middle Ages and the rise of the Enlightenment in the 16th and 17th centuries (Kjellgren & Wagelie, 2022).

Troublingly, little has changed about the curriculum-as-written. As high school teachers in Quebec, Canada, we note that the ministry-directed topics for the classes we teach in mathematics and science still rely solely on the ideas, formulas, and contributions originating with Greek thought and ending with an array of dead, white, male Europeans in the 19th century. There is no curriculum which attends to traditional ecological knowledges in science, nor the contributions of women, BIPOC, or LGQBTQIA+ peoples. The origin stories of science not only erase the contributions of important people throughout the history of biology, chemistry, and physics (all while establishing these as artificially distinct fields), but also conveys a singular Eurocentric epistemology of scientific discovery. In mathematics, the case is even worse. Apart from named theorems (Chasles, Pythagoras, etc), there is no mention of anybody at all – as though the mathematics exists without a story. The names are simply tagged onto the formulas. But what is the significance of absent narratives to student learning? Foremost, historical inaccuracies in the classroom should be a source of angst for anybody whose responsibility it is to convey correct information to children. More importantly, however, we contend that the narrative framing supports white supremacy and the perpetuation of false beliefs that continue to exclude our students. The broad spectrum of cultures, ethnicities, genders, and identities of our students are far from represented in our curriculum. Students have no idea what contemporary mathematicians *do*, since there is no story at all. And in the case of science, they graduate high school with the view that European colonists were the only contributors to relevant, robust, and accurate scientific methodologies – a view which persists to this day.

A CURRICULUM OF DISEMBODIMENT: RISKY FUTURES

Three years ago, having become increasingly frustrated with the (lack of) historical framing of mathematics and science in the Quebec curriculum, we took on the task of looking at what the ministry documents might leave room for us to do so that we could respond with new culturally relevant pedagogies. In order to tackle the problem, we began to conceptualize what the effects of the absence of cultural and historical narratives might be perpetuating in our classrooms. To that end, we describe the phenomenon of distancing the learner from the narrative histories of STEM subjects through a theoretical framework we call a curriculum of *disembodiment.*

As a concept, disembodiment has long been featured in psychoanalytic, clinical, and existential literature. Psychology research emphasizes the that our feelings and habits are attributable to our sensory experiences – namely that the types of bodies we have and experiences they enable, both reflect and change our personalities and the ways we act (Robinson & Thomas, 2021). Post-pandemic research focuses on how virtual environments erase sensory and corporeal experiences of being and learning together, and where assessing physical and interpersonal cues became absent during the pandemic (Gardiner, 2021). We occupied digital spaces, such as Zoom, in "a paradoxical mix of sensory deprivation and overload" where the only bodily senses available were sight and sound (Gardiner, 2021, p. 99). Far removed from the corporeal experience of being with others in time and space, Jason Zabel (2021) critiques the lack of dynamic interactions between people as a form of disembodiment that is:

> … a discombobulating meta-plex for myriad, manic detached thinking. For simultaneity and juxtaposition and imagination without context. The perfect equation for creating what I think of as time sickness, an emotional disorientation and disconnection from the present that also somehow has us extremely locked to this moment (para. 7).

But what do these disembodied virtual states have to do with learning now that we have returned to the classroom? We know that endless scrolling, sensory inputs and the dopamine hit that comes with using our cellular phones to check out daily new "content," are increasingly part of our everyday lives. But as Zabel reminds us, "in the quest to feel the next thing, the majority of our communication has become devoid of our greatest sensing tool: our full bodies" (para. 11). We argue that the proliferation of AI generated texts, to deepfake videos, to everyone online staking claims to Truth – in essence, hostile and meaningless online interactions which proliferated during COVID-19 – exacerbated the *existing* problem that utilitarian views of the body in relation to learning already exploit.

Students, upon returning to the classroom, carry post-pandemic dissociations from the corporeal and temporal. Apprehensive to be in physical proximity to one another, students distance themselves from the expressive functions that enable engagement with others – whether the awkward gaze, the clumsy act, or the wrong answer in the classroom. Costa (2024) reminds us that "the expressiveness of another person or persons, is precisely what makes us feel at one with our own body" even if we are stuck in a paradoxical dualism of experiencing the relationship with our dys/functional body both "from within and as a foreign mass" (p.31). This dualism of "inside and out" weighs heavily on our psyche as students and teachers navigate the notion of the subject in and about teaching. If the student's body is meant to move in particular ways in relation to others, to both resist and assimilate to the norms of schooling (such as through the apprehension of material-as-taught), how can we interact with the concept of subjectivity as educators? Furthermore, if the dominant concept of the "subject" in Western epistemology "circumscribes what counts as agency [through an] intentionalist-instrumentalist paradigm of rationality… [that] privileges dominant and familiar scripts of freely chosen, contemplated, goal-driven action, either individual or collective," (Bargu, 2024, p. xv) how can we ascertain what agencies students feel they have, that enables them to ask questions about the rationale for their learning vis-à-vis the (a)historical script through which it is conveyed by educators?

Looking at schooling in general, we might turn to Bourdieu's concept of *habitus* to understand the cultural and social power of the school as an institution in relation to the body. The socialization of students – the "lasting depositions" that are inculcated into student brains, result in the production of individuals at the end of their education who have the propensity to think, feel, and act in very specific and designed ways (Wacquant, 2005, p. 316). Pedagogies, as dictated by Ministries of Education and heavily influenced by industry, trickle down to our classrooms and change our mindsets, as teachers and learners, about the very purpose of education in particular subjects. Bourdieu describes *cultural capital* as vital to the development of social power relations. Cultural capital – which is different than the material capital of economies – is central to notions of progress, class difference, and by extension, domination and control (Bourdieu, 1986). Cultural capital is held by, and is different within, different social groups – say blue-collar versus white-collar workers, or men versus women and people of other genders. Chatterjee (2020) explains, "[s]ocial space according to Bourdieu, is a place fraught with symbolic struggles, between those who have the greater symbolic capital to impose their scheme of classification as the legitimising vision, and those who have far less symbolic capital" (p. 341). In the theorizing of student bodies as objects within the social schema, we contend that students are shaped through the latest trends in the social and economic habitus, increasingly detached – and hence disembodied – from historical, narrative and tangible experiences in their education, and are taught to strive for greater social and economic power through STEM learning. We return here to Zabel (2021) who asks us if it is possible to "still live in the corporeal [world], where you may, on occasion, have to sit with yourself and sense your way through complexity using your actual physical form" (para. 16).

Of course, learning is fundamentally about complexity – of social norms, intellectual work, emotional life, and all of the things that make up one's existential being. In STEM learning, however, the corporeal experience is often in juxtaposition with the utilitarian goals of the capitalist machine. The mathematics taught in schools is what Barton (2008) names Nearly Universal and Conventional Mathematics (NUC), and constitutes a perspective that mathematics is rational, objective and neutral. In other words, it is meant to be detached from the learner, an abstraction of concepts which churn out predetermined answers to carefully crafted questions. By extension, this form of mathematical thinking valorizes power, progress, and finite solutions to large problems – with mathematics in service of these ends. O'Neil's (2016) bestselling book *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy* explores the very problem of mathematical algorithms being used in domains such as insurance, advertising, weapons development, and even education. "Big data," she argues, amplifies inequalities by optimizing economic gain that often further marginalizes underserved communities and reinforces racism. Similarly, discourses from the Canadian government about STEM education are generally centred on workforce expansion and increasing economic productivity (Council of Canadian Academies, 2015). Think tanks and research groups are invested in increasing STEM employment in service of higher GDP. Employability in STEM fields is often the topic of conversation when university, college, and military recruiters come to schools to speak to graduating students. The sales pitches for post-secondary education centre on employability in computer programming, engineering technologies, data science and other technical fields. The value of learners as human capital in the endeavor to further STEM participation in service of economic value is in plain view.

In contrast to this perspective, Bishop (1990) explains that being mathematical (and scientific) can look different in many cultures. He draws upon the Navajo notion where "everything is in motion" (p.52). Mathematics is thought of as relational – a system of logics entirely different than the Western conception. Bishop emphasizes that "if your culture encourages you to believe… that everything belongs and exists in its relationship with everything else, then removing it from its context makes it literally meaningless" (p. 57). So what does this say about schooling where the context of mathematics education is far removed from key issues such as climate change (Barwell, 2018) or Indigenous conceptions of science and the universe (Little Bear, 2000)? Is it possible to educate students to think about mathematics and science as not just as economically important but as subjects aligned with, and in service of, an *embodied* existence?

CULTURALLY RELEVANT PEDAGOGY IN THE STEM CLASSROOM

Our goal as teachers is to address the emotional conditions of learning as increasingly disembodied by re-humanizing and decolonizing our classroom spaces and pedagogies. The project of challenging white supremacy and the distortion and disembodiment of mathematics and science as deployed through NUC mathematics and utilitarian STEM discourses is gargantuan. However, we feel that it is our role as educators who will be the in classroom for many years to challenge oppressive pedagogies that continue to alienate our students by re-storying our subject material. Part of this is to identify the existing paradigm with students – to name and expose the habitus which they occupy and reveal how years of education prior to our classes has storied the subjects we teach, sometimes in damaging ways.

Part of the challenge in teaching STEM courses is the perception by students that our subjects are difficult, irrelevant to their real lives, or even worse – traumatic. Many of our students have repeated mathematics in previous years or had a tenuous relationship with science, struggling with memorizing swathes of discrete facts. Some students have also revealed that their socialization in mathematics during elementary school was influenced by teachers who themselves were not subject-matter experts and referred to mathematics as hard or not enjoyable. We have heard from students over the years that they were rewarded for "just getting through this hard stuff" in order to go on to more fun tasks such as art projects or extended recess. Many elementary students have little to no science instruction or it is limited to explanations and diagrams rather than experimentation, observations in nature, or learning about indigenous traditional ecological knowledge.

On the other hand, many students do have a positive relationship with mathematics and science, feeling like they are good at it when they receive praise for completing tasks with correct solutions. Similarly, many students reveal that they enjoy various aspects of science outside of school, such as space, animals, human anatomy, and robotics, among other topics. However, we notice a disconnect between the rote learning from PowerPoint slides that often accompanies these subjects in prior grades and the students' natural love of learning new things. Students are keen to share interesting YouTube videos with us about a wide array of science topics but are reticent to engage in what they call "death by PowerPoint" in class, memorizing facts from the prescribed curriculum.

Hinds-Rodgers (2023) reminds us that we are all shaped by our socialization early on in school, and that "academic and, in particular, mathematical trauma is connected to the ways in which our perceived ability and attached value are experienced through punishment and reward" (p. 115). She advocates for trauma-informed practices by educators, asking them to answer questions prior to teaching, such as "do the early expectations people had for you still resonate with who you are now?... What prompted you to disrupt the cycle?" (p. 118). These kinds of reflexive practices are important for all teachers, who need to inspect their earliest memories of schooling. We considered Hinds-Rogers' questions as part of our work in this paper, beginning with documenting our experiences of learning mathematics and science. We asked ourselves the question of whether we consider ourselves mathematicians and scientists or "merely" teachers, and looked at our own cycles of reward and affirmation leading to a love of the subjects we teach – feelings we know might not be shared by the students in our classrooms.

In our efforts to disrupt the habitus of "teacher" as one who enthusiastically but perhaps unquestioningly transmits the curriculum-as-written, we take on a culturally relevant pedagogical (CRP) approach inspired by the well-known work by Gloria Ladson-Billings (2015). CRP is "a pedagogy that empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills and attitudes" (Ladson-Billings & Tate, 1995, p. 52 as cited in Hinds-Rodgers, 2023, p. 120). We began by examining the three main pillars of CRP to understand how we might "hack" the Quebec curriculum to better serve our students. These pillars are represented below:

Culturally Relevant Pedagogy (CRP)		
Pillar 1: Academic Achievement Hold high and transparent expectations; presuming all students can succeed. Think deeply and critically about what they teach, and why they are teaching it.	Pillar 2: Cultural Competence Understands culture and its role in education; actively developing their own and their students' cultural competence.	Pillar 3: Sociopolitical Consciousness View education as one pathway to liberation by actively developing their own and their students' cultural competence and sociopolitical consciousness

Pillars of culturally relevant pedagogy
Source: Adapted from Ladson-Billings (1995) in Hinds-Rogers (2023).

As we looked at our curricula, we developed key questions to prompt our thinking about how we might make changes to the way we convey our subject material:

- What is the hidden curriculum of the subjects we teach (science and mathematics)?
- How do our identities currently shape our classroom practices?
- How can we reshape and restory our curriculum to be more culturally relevant for our students?

The courses we chose to examine are Grade 9 Science (Tasha) and Grade 11 Cultural, Social and Technical Mathematics (Catherine) because these classes represent the majority of our courseload (multiple sections per day). Grade 9 science focuses on the basic principles of chemistry and fluids, human biology, and some technical engineering. Grade 11 Cultural, Social and Technical (CST) mathematics covers linear optimization, graph theory, financial math, probability, voting theories, and geometry. When we examined our Progression of Learning (POL) documents from the Ministry of Education in Quebec, alongside curricular materials commonly used and provided by the school board, located in textbooks, or shared by colleagues, we noted the following common themes, which constitute the hidden curriculum of our subjects:

- Mathematics concepts in Cultural, Social and Technical mathematics lean towards the technical with no references to real data or social/cultural issues. Rather, students are asked to perform computations with real-life applications using theoretical or banal examples (i.e the number of fruits in a basket, measuring a garden, or calculating the probability of marbles in a bag).
- Mathematics is presented as a universal pre-existing truth that it is discovered and not created by human beings.
- Topics are presented in isolation as though they are independent: algebra, geometry, and so forth. Similarly, biology, chemistry, and physics topics are taught as distinct and not interrelated.
- Science concepts in grade 9 are explained as theoretical with no reference to scientists at all (i.e. the model of the atom is simply presented with no discussion about its origins or accuracy).
- Human anatomy is presented as deterministic and genetically immutable – namely that there are two iterations of biological sex and that people are simply the product of their genes.
- Topics such as Genetically Modified Foods (GMOs), Vaccines, In-Vitro Fertilization and other biotechnologies are presented as value-neutral. Only human cloning is presented as a topic of controversy, but in the sense that it is banned "because it is unethical." Bioethics is not a topic in the curriculum.

Even though other sub-themes emerged, we used these general themes as the basis for implementing changes to our lesson plans. We also thought about our identities in relation to learning the curriculum in secondary school three decades ago. We note the irony that despite huge advancements in the fields of mathematics and science since we were in high school, we are asked to teach almost exactly the same concepts and principles we were taught. We feel extremely attached to these concepts and the positive feelings associated with our success in mastering them. However, an important final theme might be that our curriculum does not represent the current state of research and advancement in our fields, nor do our lessons indicate to students that the fields of science and mathematics are dynamic and changing. To that end, we need to challenge our emotional comfort with reproducing the curriculum-as-written in order to become culturally responsive.

IMPLEMENTING THE CHANGES: A NEW WAY OF LEARNING

To implement a culturally relevant curriculum that corrects the historical inaccuracies in our subjects and introduces cultural and social contexts of mathematics and science, we proceeded unit by unit. We laid out our curriculum topics in the order they are presented and then asked what kinds of new projects, methods of assessment, and culturally relevant topics might be introduced.

Figure 1: Multicultural mathematics poster set from Spectrum Ed (spectrumed.ca)

Our first task was to change our classroom spaces. We adopted new classroom décor to reflect the dynamic history of our subject areas. Catherine installed a series of posters around her classroom featuring math from around the world (Figure 2), and Tasha added posters of Rosalind Franklin and a book corner featuring *Radium Girls, Hidden Figures,* and *The Immortal Life of Henrietta Lacks.* As well, after noticing many students were artistic, carrying around sketchbooks to all of their classes, Tasha began drawing biological images in chalk instead of projecting them, so to spark conversations about scientific illustration and the role of artists in science (Figure 3). Finally, Catherine rearranged her class desks to pods in mathematics, to promote conversation and group work, and also installed vertical whiteboards so that daily randomized groups of three could discuss the topics at hand. Tasha similarly changed seating into teams and created stations around the lab benches for students to work together and discuss topics.

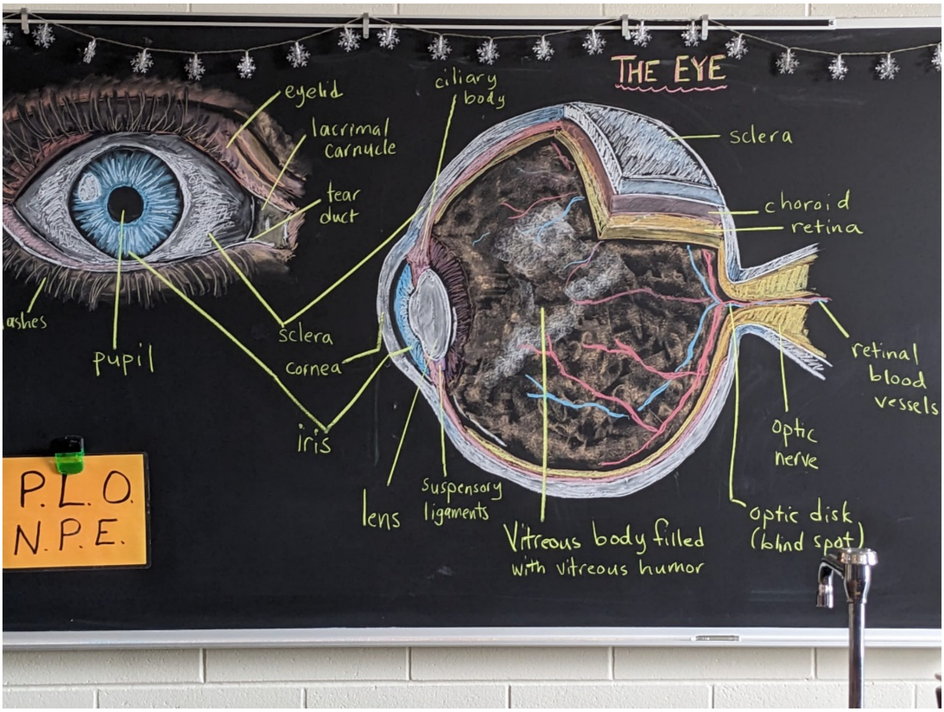

Figure 2: Chalkboard drawing of the eye in grade 9 science from Tasha's classroom

Once our classrooms were physically compatible with the changes we wished to make pedagogically, we began to develop new lesson plans and projects for students to have more voice. In mathematics, this took the form of graph theory poster projects where students could choose any topic and present their knowledge of graph-theory concepts as related to a real-world issue. The topics ranged from epidemiology to GPS to plot development in movies (Figure 4). The students then had a poster fair to share their findings with peers.

In the voting theory unit, students discussed different voting methods from around the world and debated the ethics of vote counting. They were appropriately enraged that no single voting method – theoretical or implemented – reflects the true desires of a given population, which led to interesting debates about whether their future vote will count in a democracy such as Canada's. Students also attempted to generate new voting methods that might more accurately defend the views of citizens. They collected data and presented their findings about who would win a school vote depending on whether the Borda count, Condorcet method, majority voting, or proportional representation was used. Of course, the winners were not always the same, sparking further debate about the student preferences which were surveyed, and how votes are counted in school for special events like field trips and prom.

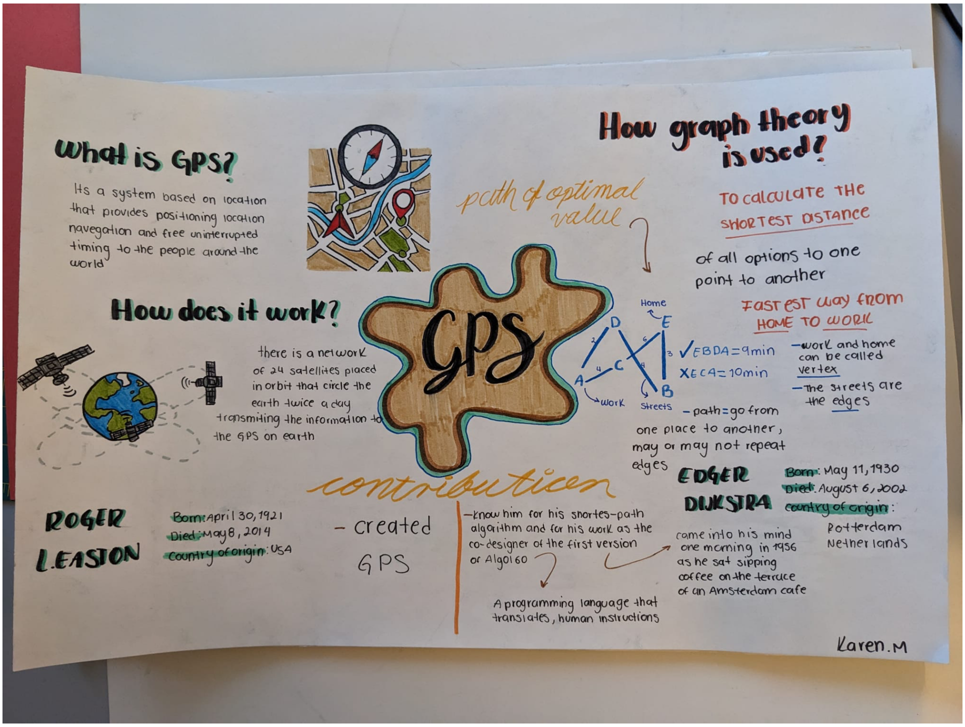

Figure 3: A student poster about GPS as related to graph theory

For probability, grade 11 students held a casino in the school cafeteria, using real poker chips and gaming devices (playing cards, spinners, and so forth). Grade seven students were invited to participate in the casino and teachers brought the classes down to play. If students ran out of chips, they simply had to answer a trivia question to get a new batch. This provided an opportunity for students to design games as a casino would do (ie favoring the house) and understand both the mathematics and ethics behind gambling. Additionally, students from higher grades were able to interact with those from younger ones and enjoy a day together, playing the games and testing their trivia when they needed more chips.

In geometry, the students were introduced to the intricacies of tessellations and tiling, beginning with a video from *TedEd* called "The complex geometry of Islamic design." They then created their own fourfold, fivefold, or sixfold geometric patterns and were encouraged to share their experiences with seeing tiling. May students in our school are from in South America, African countries, the Middle East, Spain, and other places where tiling is a common geometric and artistic form. Students were able to share stories from their families and cultures, and from their homes and religious centres in Canada and abroad.

Figure 5: A page from a student's final project comic book about financial math

Finally, instead of final exam, students were given the option to represent three of the units from the school year in any manner they saw fit. The results were surprising and innovative. Students created entire comic books (Figure 5), podcasts with such titles as "Opti-my-say-something," sports-desk radio shows with mathematical fantasy-football style contenders (and their stats), short fictional stories including one about a village who had an impending vote on a key topic that would change the course of history, and hip hop video performances. The students generated their ideas and submitted assignments far beyond the imagination of the teacher, creating new forms and expressing themselves in ways that were most comfortable for them to convey their knowledge of the content.

In science 9, new activities were created to better address the different learning styles of students. Similar to the math context, instead of a unit exam for the fluids unit, students were able to make concept maps or a poster related to a specific case study, analyzing it using the principles of fluids (i.e. the US Airways flight 1549 which landed in the Hudson River). Students took wildly different views of the project, some painting images of the case studies and overlaying the science principles, while others made concept-map style flow charts.

In the reproduction unit, students were presented with the concepts of intersex anatomies, gender fluidity, epigenetics, and other topics to disrupt the concept of genetic determinism. For many students, this was a relief as they expressed distress that their anatomy did match stock images from textbooks and wondered if all body parts were supposed to look like the ones presented (ie symmetrical breasts, large penises, and conventional body shapes). For most students, whether approaching or going through puberty, or for those on puberty blocking medications, the discussions about different types and rates of development, the differences in bodily anatomy, and the inaccuracies of textbooks in representing all anatomy on white bodies became a passionate discussion. As well, students challenged the textbook images of bodies with genetic disorders presented with eyes covered with a black box. They noted most often, the children and young adults in the images were obviously from poor countries or conditions where medical intervention was not available or overlooked. The students agreed that the images were disturbing because we were sitting in Canada consuming the pictures as a kind of "freak show" and offered the suggestion that perhaps diseases and disorders could be presented in a more equitable way that didn't (quite literally) erase the people in the pictures.

After Christmas break, Tasha began brainstorming ways to integrate Black history into the curriculum, in conjunction with Black History Month in February. She showed the film *Hidden Figures* to students and discussed the mathematical contributions of Katherine Johnson and her colleagues to the space program at NASA. As well, the students learned about the complex and tragic history of Henrietta Lacks, whose cervical cells (HeLa) cells were harvested without her consent and continue to be used as a cell line for cancer research to this day. This knowledge sparked a debate about the use of the cells, and also linked back to the film, as students' first question is always why Black women were not recognized publicly at the time for their contributions to science – whether those contributions were consensual or not. And for Henrietta Lacks, the students learned about the ongoing struggle her family faced for recognition and financial compensation in her name, largely without success. Students have a strong sense of justice, particularly in middle and secondary school and are horrified that not only have they never heard this history before ninth grade, but that these women remain largely unknown in the public imagination. They express similar feelings of outrage about Rosalind Franklin who was not given the Nobel Prize alongside her male counterparts, Watson and Crick, for her contributions to the discovery of DNA.

In a discussion of the biotechnology unit, students were asked to brainstorm things they had heard about vaccination, IVF, GMOs, cloning and more. Students were quick to bring up issues about global sustainability, their fears about genetically engineered babies or super-soldiers, and the trauma of having environmental disasters placed on their generation. They expressed that in previous classes, questions like, "how can your generation clean up the great garbage patch in the Pacific Ocean?" or "what can you do about clearcut logging?" distress them because they are inheriting the damage done by previous generations. This became formative for the teacher in terms of how to bring up issues around climate change and ecological destruction because students expressed that they get overwhelmed. They admit becoming apathetic about world issues due to anxiety. Students directly expressed knowing that the minerals used to make their cell phones might have been mined by children in countries in Africa. However, they expressed feeling caught between the guilt of using the phone and the expected consumerism that "everyone has one." This discussion has become the impetus to look for ways to integrate traditional ecological knowledge (TEK) into future curriculum even though environmental science is not explicitly in the grade 9 Progression of Learning. Students need to experience alternate worldviews about the land beyond its use value to us as mass consumers.

DISCUSSION

Through our new changes in our classrooms over the past three years, we have tried to disrupt the notion that students are mere human capital, learning prescribed content in ways designed for a utilitarian future. Our foremost goal was to increase student voice and experience in the learning process while still conveying the material prescribed in the curriculum. We also wanted to acknowledge the colonial logics that underpin the school as an institution whereby certain kinds of knowledge and assessment strategies (ie testing) are promoted as yielding the most accurate data about children. Removing the mentality of students as data points linked to institutional outcomes helped us understand our learners more holistically – as artists, creators, inventors, BIPOC, and LGBTQIA+ identifying persons.

We attended to the three pillars of Ladson-Billings' (1995) CRP model by first examining the curriculum-as-written to ensure that we would cover all of the required topics, and still have appropriate, scaffolded, and authentic assessments for each student. To build cultural competence, we encouraged students to integrate their interests and cultural backgrounds into the assignments and projects they completed – from using their artistic capabilities to sharing stories of their cultures, languages, and genders should they wish to do so. Cultural competence is heavily linked to the third pillar, socio-political consciousness, as students questioned the textbook representations of race, gender, and disability, and the ways that voting is organized in various contexts. They were able to question the pedagogies of bioethics and climate change, challenging the commonplace discourse of "saving the planet" through their emotional experiences with being confronted with catastrophic problems as small children.

Returning to questions of embodiment, we hope that our students feel that they have agency and voice in our space. We addressed head-on the fear, and perhaps full-blown existential crisis, that many students express in the internet generation – that because they can Google everything, they know nothing and are walking around like empty vessels – a kind of "excarnate" view of the body – a "brains in the vat…" or a self that consists "of nothing but contingent psychological associations (i.e. subjective continuity granted by memory and character" (Costa, 2024, p. 32). This corporeal distancing is hard to confront, but we continued to ask students to reach into their lived experiences, desires, and histories to lend insight into their learning, as well as ask *why* they should learn the content we present. By rearranging the ways that we teach – through collaborative note-generation instead of didactic notetaking, small-group discussions, open-ended projects, and difficult whole-class debates, students interacted with one another and asked themselves and others about their place in the world. They were able to challenge the ways history is written and who it excludes. Through guided discussions about historical figures such as Rosalind Franklin, Katherine Johnson, Maryam Mirzakhani, Alan Turing and Henrietta Lacks, we were able to at least partially re-story the development of 20th and 21st century mathematics and science. Going back even further, we presented indigenous, ancient, and pre-Greek histories in our classroom as the epistemological basis for our subjects, starting on day one of the school year. By changing the fundamental paradigm, we hope to help rewrite the script, alongside our students, of what it means to "do" mathematics and science, and who gets to do it.

REFERENCES

Bargu, B. (2024). *Disembodiment: Corporeal Politics of Radical Refusal*. Oxford University Press.

Barwell, R. (2018). Some thoughts on a mathematics education for environmental sustainability. In P. Ernest (Ed.), *The philosophy of mathematics education today* (pp. 145-160). New York.

Bishop, A. J. (1990). Western mathematics: The secret weapon of cultural imperialism. *Race and Class, 32*(2), 51-65.

Bourdieu, P. (1986). The forms of capital. In J. G. Richardson, *Handbook of theory and research for the sociology of capital* (pp. 241-258). New York.

Chaterjee, I. (2020). The Muslim: Islamophobia as disembodiment. *Culture and Religion, 21*(4), 339-358.

Costa, P. (2024). Embodiment, Disembodiment, and Overembodiment: Merleau-Ponty, Foucault, and Augustine on the Significance of Sexuality in Human Life. *Annali di studi religiosi*, 29-47.

Council of Canadian Academies. (2015). *Some assembly required: STEM skills and Canada's economic productivity.* Council of Canadian Academies.

Friberg, J. (2007). *A remarkable collection of Babylonian mathematical texts: Manuscripts in the Schoyen collection cuneiform texts I.* (Vol. 1). Springer.

Gardiner, L. J. (2021). Moving bodies: Countering digital embodiment. In J. Birch, *Coaching supervision groups: Resourcing practitioners* (pp. 96-108). Routledge.

Gerdes, P. (2008). Mathematics in Africa south of the Sahara. In H. Selin (Ed.), *Encyclopaedia of the history of science, technology, and medicine in non-Western cultures.* Springer.

Hinds-Rodgers, C. M. (2023). Fostering a positive mathematical identity for students and teachers by attending to the academic trauma caused. In K. Porcher, R. Ramkellawan-Arteaga, C. HInds-Rodgers, & J. Bell (Eds.), *From being woke to doing #theWork: Using culturally relevant practices to support student achievement & sociopolitical consciousness* (pp. 111-124). Brill.

Kjellgren, E., & Wagelie, J. (2002, October). *Easter Island in Heilbrunn Timeline of Art History*. Retrieved from The Metropolitan Museum of Art: https://www.metmuseum.org/toah/hd/eais/hd_eais.htm

Ladson-Billings, G. (1995). But that's just good teaching! The case for culturally relevant pedagogy. *Theory into Practice, 34*(3), 159-165.

Ladson-Billings, G., & Tate, W. F. (1995). Toward a critical race theory of education. *Teachers College Record, 97*, 47-68.

Little Bear, L. (2000). Jagged worldviews colliding. In M. Battiste (Ed.), *Reclaiming Indigenous voice and vision* (pp. 77-85). UBC Press.
Nicholas, G. (2018, February 21). *When scientists "discover" what Indigenous people have known for centuries*. Retrieved from Smithsonian Magazine: https://www.smithsonianmag.com/science-nature/why-science-takes-so-long-catch-up-traditional-knowledge-180968216/
O'Neil, C. (2016). *Weapons of math destruction: How big data increases inequality and threatens democracy.* Crown Publishers.
Robinson, M. D., & Thomas, L. E. (2021). *Handbook of embodied psychology: Thinking, feeling, acting.* Cham, Springer.
Wacquant, L. (2005). Habitus. In J. Becket, & Z. Milan (Eds.), *International encyclopedia of economic sociology.* Routledge.
Zabel, J. (2021, October 19). *The disembodied internet: Why we all feel like no bodies online*. Retrieved from Medium.com: https://medium.com/@jasonzabel/the-disembodied-internet-why-we-all-feel-like-no-bodies-online-ac97df4a2721

TASHA AUSMAN, PhD, is an LTA Professor at the University of Ottawa and a full-time mathematics and science teacher with Western Quebec School Board in Gatineau, Canada. Her research employs decolonizing, psychoanalytic, and post-colonial frameworks in the areas of Curriculum Studies, STEAM, and Queer Studies. She is currently working on research approaches to decolonize science and mathematics teaching in secondary classrooms, and on employing curriculum studies frameworks to understand the intersection between visual-arts-based pedagogies and biology. Email: tausman@uottawa.ca

CATHERINE JAMES, PhD, is a Part-Time Professor at University of Ottawa with the Faculty of Education, and full-time mathematics teacher with Western Quebec School Board in Gatineau, Quebec. Her teaching employs anti-racist and culturally relevant pedagogies. Her research interests include mathematics education, assessment, 21st century pedagogies, and curriculum studies. Email: cjames@uottawa.ca

NOTE: The authors did not use OpenAI's ChatGPT or any other AI tools in the drafting, editing, or refining of this manuscript. All content was generated, reviewed, and refined solely by the authors.
