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"Don't Vax Up"

The Real-Time Failure of Public STEM Education in the COVID-19 Era

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Abstract

Although many other factors come to bear on present issues in the contemporary world, vaccine hesitancy and refusal are also the direct result of poor STEM education. In this article we employ a sociological thought experiment methodology to articulate the shortcomings of STEM education and suggest pathways for much needed changes in solving future pandemics and other 21st century challenges. The problems we expose in STEM education include unequal access to high quality education via inter and intra school tracking and curricular issues where STEM does not integrate with other disciplines, like social studies, and fails to engage a critical perspective on STEM informed by advanced philosophies of science and epistemology.

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Introduction

Over the past two years, most of us living and teaching are doing so amidst the largest social uprising of our lifetimes from the Black Lives Matter movement, to Climate Change Protests, to overall dissent against the rise of tyrannical governments around the globe. Additionally, the modern world was brought to a deadly planetary pause by the pandemic COVID-19. Following an entire academic calendar year and school run amok for most of the children in the United States, this article concept came about in the summer of 2021 when the United States witnessed a slowing down of COVID-19 vaccination rates and newspaper headlines called for a new scenario of illness and death: “A Pandemic of the Unvaccinated.” As researchers with a comprehensive understanding of scientific knowledges and how they complement other ways of knowing, we felt a sadness to witness these new developments. Hospitalizations, significant illness, and death cropped up again with a new COVID variant. One New York Times article (Healey, 2021) from the summer of 2021 profiled a woman who deeply regretted avoiding the vaccine due to misinformation she received about it; now her 42-year-old husband was fighting for his life in the Intensive Care Unit. She described the onslaught of misinformation leading to her earlier decisions and how these efforts continued even after her husband became very ill. Misinformation like the discourses surrounding vaccinations is directly in relationship with the rise in governmental tyranny and sadly we are writing this from within a country that is internally struggling to maintain a democracy with the possibilities of centering on human rights, justice, and sustainability. While we the authors most certainly understand the complexities that have led up to the protests and pandemic of 2020, we want to remain hypervigilant and focused on taking seriously the responsibility for educators—especially STEM educators—to teach the importance of recognizing and valuing truths, navigating what we refer to as the false equivalency trap, and plain and simple learning from and valuing scientific consensus. Timothy Snyder (2017) in *Twenty Lessons from the Twentieth Century* refers to the importance of believing in truth and wrote: “To abandon facts is to abandon freedom. If nothing is true, then no one can criticize power, because there is no basis upon which to do so. I nothing is true, then all is spectacle. The biggest wallet pays for the most blinding lights” (p. 65).

As we continued to work on the article, we also viewed Adam McKay’s 2021film “Don’t Look Up” and the parallels to its satire about climate change. The realities we experienced in the pandemic were all too apparent. The film’s climactic moments of polarizing discourses, with the emergence of half the US population donning “Don’t Look Up” hats gave us a striking visual: it was as if we could replace the slogan with a “Don’t Vax Up” version of red hats. To be clear, our title calls attention to the vaccine hesitancy and refusal running rampant throughout the US and other countries; by no means are we suggesting that this continue. Rather, in this article we embark on a sociological thought experiment to examine the dangers of misinformation and what emerges for us through our research on STEM education and in particular as critical math educators and how mathematics education as part of STEM might better support the importance of learning to understand and value scientific consensus as an important advisory to decision-making and ultimately to democracy.

Navigating governments through how to protect the human populations of their countries and states, scientists—especially medical health professionals and disease researchers—instantly were at the forefront of informing us all on the best protocol for slowing and stopping the spread of COVID-19 and any variants. Following a year of pandemic outbreaks around the world in 2020, the scientific community clearly saw the problem but within it had differing approaches to help address the issue. Hotez (2021) experienced "sinking feelings during [the] zoom calls" about anti-vaxxers and what the medical profession should do about them. He describes others' milquetoast approach and his own perspective as follows:

> I have a long-standing disagreement with many of my US public-health colleagues. I admire their commitment to disease prevention, but when I ask for a more direct way to counter anti-vaccine aggression, I'm told, 'that's not our approach; confrontation gives them a platform and oxygen.' In my opinion, this attitude reflects a time when we had dial-up modems. Today, the anti-vaccine empire has hundreds of websites and perhaps 58 million followers on social media. The bad guys are winning, in part because health agencies either underestimate or deny the reach of anti-science forces, and are ill-equipped to counter it. (p. 661)

Hotez further describes the bad guys as a confluence of at least two entities: 1) Russian and other political groups that need new fodder for destabilizing the US now that the Trump era has waned and 2) an existing, formidable anti-vaccination network that deliberately targets US folks from all walks of life, for example by crying out the vaccine as "medical racism" to Black, Indigenous, and People of Color (BIPOC). These are the types of highly organized groups that sent the young woman from the Times article boxes and boxes of horse pills that they said would cure her husband of COVID.

As researchers in education, we hesitate to inquire more into these networks and geopolitical scenarios that fuel the swell of anti-vaccination sentiments causing so much sickness and death in the country and beyond (given the US's contribution to the proliferation of more deadly variants of COVID). What is within our domain of inquiry is to question and study exactly why so much of the US population falls prey to these fanciful anti-science arguments by suggesting and correcting the pitfalls in US public education. Yes, the "bad guys" as Hotez puts it, exist and are the real problem. We see them as the powerful in this situation and those that hesitate for a COVID vaccine as victims. Thus, we are careful not to victim-blame those that hesitate and offer instead an accompanying provocation: those that hesitate and deny the vaccine are also the victims/products of bad STEM education in the US public education system. Yes, the geopolitical scenario and anti-vaccination network are the sources of tragedy. However, to us as educationists, equally tragic is the populace who receives *and believes* these messages uncritically, without a means for thinking through and questioning for betterment of the individual and society. In the following section we put to use the concept of a sociological thought experiment and propose a method to understand what we might learn if we describe the current failure scenario in the context of learning to navigate a vast sea of misinformation and propose swift and urgently needed curricular and pedagogical changes STEM education that focus on democratic skills for decision-making, justice, and sustainability given we are headed for a certain future fraught with sociocentric and mathematically complex issues like global pandemics.

Sociological thought experiments

Sociological thought experiment is our method of choice in the present inquiry. The sociological version is but one of many types of thought experiments, methods holding great productivity in generating knowledge among the hard sciences, social sciences, and humanities. Famous examples of thought experiments come from philosophy and physics. As a physics example: Galileo used thought experiment methodology to prove that all objects fall at the same speed (Gendler, 1998) and for philosophy/morals/ethics: Thompson (1971) uses a thought experiment to squash the "right to life" argument purported by anti-abortion activists, thereby using the method to argue favorably on the ethics of pro-choice.

Sociological methods typically employ data and use quantitative or qualitative methods, just as the hard sciences do. Yet, as noted with the Galilean examples and others, the use of thought experimentation has been fruitful for sociologists as they study society's institutions and social relations. Truthfully the method is less often used in sociology than in physics and philosophy yet there are noted sociologists passionately arguing and demonstrating its utility. Hill (2003) describes five examples of thought experiments in sociology, important to note that he provides examples from sociologists who did not necessarily employ the term but their argumentation reveals insights into a sociological thought experiment method. One example describes W.E.B. Dubois' effort to bring "a white person where he or she could not enter reality" (p. 9). In this thought experiment, he speaks directly to white people as he portrays the lived experience of Black people in a segregated and white supremacist setting. "DuBois, using the framework of a thought experiment, helps those on the other side of the color line explore and better understand a world they cannot easily enter in real life" (p. 9).

Hill also writes on the necessity of sociological thought experimentation because this can increase the potential areas of inquiry. It may be the case that collecting empirical data is too costly, too harmful, or take too long. Hill reminds us of C. Wright Mills focus on the importance of reasoning as a complement, and in some cases supplement, to work with empirical data. Hill writes on the expansion of what is possible via the sociological thought experiment:

> Indeed, what if the world and its large, readily available data sets are expressly organized to deceive and obfuscate the actual state of things? What if institutional review boards, for example, are effectively—possibly nefariously—designed to keep us from learning anything sociologically damning about powerful elites, in general, or about high-ranking university officials, in particular? What if we undertake research projects on elites "without authority or official aid?" What consequences might befall us? Such questions are the very stuff of thought experiments; they help us avoid the methodological traps of mistakenly taking our sociological world for granted. (p. 7)

With these motivations for using a thought experiment methodology in sociology, we also have sociologists who recently help to define the method concretely. Betta and Swedberg (2021) also emphasize the power of thinking for sociology and describe attempts to use thought experiments by such sociology greats as Durkheim and Weber. Ultimately, they suggest that good sociological thought experiments are "analytically sharp," have a "minimalist structure," and a "transparent process that follows a sociological logic" (pp. 157-158). Here they define a sociological thought experiment and its parts:

> The suggested definition of a sociological thought experiment reads as follows: *an experiment that is carried out in the mind of the researcher, in which imaginary data are used, and where the unfolding logic is sociological.* It is possible to distinguish different stages in such an experiment: the initial social state (I); the

> introduction of a specified change (II); the social process now set in motion and worked out in the mind of the analysis (III); and the end state (IV). (p. 144)

This article presents an initial use of the method as applied to the sociological study of education, possibly the first of its kind. As such, we present this article as initial thinking by us and for invitation in discussion. Indeed, the problem addressed in this sociological thought experiment is fraught with many angles and many issues. For example, in our initial stage, we will suggest only a few of the present problems in the initial state of US public education that contribute to the anti-science populace we see today. We invite readers and scholars in the study of education and society to contribute additional ideas that contribute to the problem state. Similarly, we briefly sketch out a specified change to address these shortcomings and suggest a timeframe in which these changes will occur, all for debate and discussion as to our logic and ultimate choices in the thought experiment. While the thought experiment can make unequivocal claims in physics and even sometimes in philosophy, we hesitate to state that a sociological thought experiment can be entirely conclusive but instead an offering for discussion and debate. Indeed, yet another of Betta and Swedberg's key characteristics of a good sociological thought experiment is its capacity to "spark discussion" (p. 158).

Status quo failures in STEM education

In the initial phase of the thought experiment, we used our knowledge of existing research in STEM education and education research more generally to focus on the most essential issues facing STEM education that result in an anti-science populace swayed by anti-vaccination discourses. The status quo failures are divided into two parts: curricular shortcomings and structural shortcomings. Regarding the former, curricular challenges include the lack of socio-scientific issues in STEM curriculum, the objectivation of mathematics with a "dissolution of responsibility" (Skovsmose, 2011), and the failure of STEM education's relationship to other ways of knowing the world. As for the structural shortcomings, we reveal the relevance of education studies and STEM education studies concepts like the tracking, education debt, and opportunity gaps to the problem at hand.

Curricular Defects

Since the 1960s, there has been much progress in STEM educational research that offers (at least some students - see the next subsection on structural issues) STEM material as a process primarily rather than as a content. In mathematics education, for example, the signifiers "reform mathematics" and "new math" and "standards-based" are somewhat synonymous and refer to problem and reasoning-based classroom learning in which students engage in constructive learning of the material. Similarly, "inquiry" and "the learning cycle" in science classrooms has shifted expectations for students to learn the process of science more than a direct focus on the content topics. Although rigid expectations of a traditional set of content mastery still exist (and we are thinking of how these are reflected in standardized tests, reactionary parent groups, and a few traditionally-minded teachers) on the whole textbooks and state and district curricula are reflecting this shift. It is also certainly the case that the shift towards process-oriented content is reflected in the national blueprints for content standards such as the National Council of Teachers of Mathematics (NCTM) 1989 and 2001 standards, the Common Core State Standards for Mathematics from 2010, and the Next Generation Science Standards (NGSS) of 2013. Overall, these shifts are good efforts in getting more students to understand what mathematics and science do and can do for us, and we expect that these will continue to gain more and more success as years continue.

There are, however, gaps in this approach that directly relate to poor STEM education for grappling with social issues like a pandemic. One of these comes up similarly for both mathematics and science education: neither do a particularly good job of relating the process and thinking of STEM to social life. Science education has a niche area of inquiry titled socio-scientific issues (SSI) that receives interest among the research community, but this has yet to be integrated fully into curriculum. For example, Ewing and Sadler (2020) describe the importance of integrating socio-scientific issues in science classrooms as follows:

> Engaging with science in ways that are meaningful, authentic, and relevant is of increasing importance in the science classroom. One way to provide these opportunities is by using socio-scientific issues in instruction. Socio-scientific issues are societal challenges which are both scientific and social in nature (e.g., climate change and water pollution); such issues are inherently authentic, consequential to society, and abundant in the news. (p. 18)

They continue with rich descriptions of SSI topics, like water pollution, and the pedagogy involved in teaching them. Ewing and Sadler engage the NGSS and specifically its "systems" standard as a link between the inclusion of SSI in classrooms and the national blueprint for science instruction. They quote from the standard, a perspective emphasizing that a system works when all its parts can function together as a whole, as a link to help students see how social systems (that are scientific in nature) must work holistically. We agree with this perspective and add that, in our view, this link between SSI and the standards is weaker than it could be and signifies that SSI is not given proper space in the curriculum. There is no NGSS standard directly stating the importance of including SSI in the science classroom.

Although the NGSS does create much more space for SSI in science classrooms, the decision to include SSI in the classroom remains in the hands of classroom teachers or perhaps science departments who know about this approach through the longstanding work of Sadler (2011) and colleagues. Because this is not an official part of the explicit curriculum, we see how science education has failed to describe the role that science has in responding to a pandemic and other social issues.

Traditional mathematics education and to a lesser extent reform mathematics education are guilty of a similar flaw, that mathematical content is entirely divorced from social issues in the classroom. The Common Core State Standards for Mathematics (CCSSM) integrate several of the new approaches in reform mathematics education; one of these is reform mathematics' attention to the application of mathematical content to real-world settings. CCSSM is replete with standard after standard of this type of real-world settings, however, examples from the standards themselves as well as applications in standardized testing problems and textbooks do not integrate social issues into thinking and discussion. Applications of mathematics are reserved primarily for problems that encourage passive acceptance of a consumerist economic social life and endless engineering of new structures without consideration of the social and environmental impact, among other seemingly apolitical uses of mathematics.

These uses of mathematics are purported to be objective and value-free yet, quite the contrary, are highly political and entangled with social life. Skovsmose (2011) describes how this is indeed a feature not unique to mathematics education, but endemic to the Eurocentric mathematical culture as a whole. He describes the failure of mathematical thinking that divorces itself from its social impact as central to the mathematical project and the source of sustained violence to people and other life throughout the world. This is his concept of mathematics in action that "dissolves responsibility:

> Actions based on mathematics easily appear to be conducted in an ethical vacuum. Actions we normally associate with an acting subject. However, mathematics in action appears to be operating without such a subject. And when the acting subject disappears, the notion of responsibility seems to be blowing in the wind. Mathematics-based actions may appear as the only actions relevant in the situation. They might appear to be determined by some 'objective' authority as they represent the necessity provided by mathematics. In this way the elimination of responsibility might be part of mathematical performances, which in turn makes part of a knowledge-power dynamics. (Skovsmose, 2011, p. 68).

What Skovsmose suggests is missing in our STEM curriculum is a "critical conception of mathematics" that "reflects on mathematics" that "makes part of a huge variety of actions within all spheres of life. Such actions could have all kinds of qualities; they could serve many different interests. Thus, mathematics does not preserve any sublime format. It makes part of daily-life processes as well as technological endeavors, some of which might be dubious nature" (p. 94). A critical conception of mathematics in STEM would help to illuminate understandings in the populace with respect to large and small numbers, helpful in understanding social issues like a pandemic and vaccines. They can reveal the dubious natures of the statistical methods utilized in bad STEM like Samuel George Morton's attempt to prove racial superiorities via bad sampling and the measurement of volume of skulls (Gould, 1996, pp. 82-88). Stephen Jay Gould comments on STEM's use of mathematics: "Numbers suggest, constrain, and refute; they do not, by themselves, specify the content of scientific theories. Theories are built upon the interpretation of numbers, and interpreters are often trapped by their own rhetoric" (p. 106). In Morton's case, he fudged the numbers to accord with white supremacy, even selecting white skulls from larger than average people and Black skulls from smaller than average people to let the numbers "speak for themselves" when, it was simply bad mathematics and Gould suggests Morton did so subconsciously, moved by the overwhelming social relational discourses of the historical moment. STEM education can do better to reveal both the good uses of mathematical reasoning and the bad to first knock STEM from its own pedestal of supremacy and secondly demonstrate how to critically consume STEM information. This kind of education would lend itself to better thinking, for example, about how to understand the news reports around vaccination rates and the controlled-experiment design that is used for vaccine approvals in the current era of STEM.

In reviewing these scientific and mathematical shortcomings, specifically the lack of SSI and mathematics in action in STEM curriculum, we also suggest more broadly two major features of STEM curriculum that relate to these specifics at the macro level. Generally, the lack of SSI and mathematics in action speak to poor integration of content-area disciplines. Yes, the goal of STEM is to integrate disciplines and while STEM policies and practices may have created spaces to connect mathematics and science, they fail to integrate fully with all disciplines like, for example, the social sciences and humanities.

Elsewhere (Wolfmeyer, Lupinacci, & Chesky, 2017) we have argued that STEM works as a discursive episteme that fractures hard the split between STEM and humanities/arts/social sciences. It's as if the STEM focus has created a new hierarchy of "STEM" and "all the rest."

Given this fracturing, we see that status quo STEM curriculum on the whole divorces itself from other content areas. True, branch-offs like STEAM (Science, Technology, Engineering, the Arts, and Mathematics) attempt to integrate the disciplines differently, but none of the efforts that enjoy significant attention will make significant change for social and environmental issues. With such a fracturing, there is no space, no encouragement, for example, for STEM classroom instruction to focus on the ethical discussions about medical testing and the dark histories that entangle white supremacy with very, very bad science. e.g., the Tuskegee experiments of the 20th century. If this were in place, the populace would hold the scientific community more accountable and know how to be critical of new medical innovations, more properly than they are now. However, as it stands, given a vague sense of this history (because it goes unaddressed in STEM classrooms), the populace and especially Black Indigenous People of Color (BIPOC) have a right to be suspicious of new medical innovations.

This example of distrust for science strikes to the second broad issue we see with STEM curriculum. The Tuskegee experiment is an example among many when STEM endeavors were very wrong and very bad. Despite these huge missteps, STEM continues to hold dominance among the disciplines as the "objective" method for determining knowledge. Similarly, STEM curriculum commits to a "we are right and they are wrong" approach when they could better reflect more advanced philosophies of science as one of us (Wolfmeyer, 2017) discussed via the work of Paul Feyerabend. Consider the typical science textbook discussion of "pseudoscience." While we agree that such a discussion relating the scientific method to other ways of knowing about the world is necessary in the STEM classroom, we see the present circumstance as a set-up pitting the Eurocentric scientific method against other knowledges in dangerous and unproductive ways.

See Beyerstein (1995) for example, with their thorough explication of the "pseudoscience" that is Traditional Chinese Medicine (TCM). This curricular document suggests teaching students to outright reject TCM given its lack of comportment with Eurocentric scientific methods. Imagine a student in the classroom who has family members who practice TCM; how is this student to receive this instruction and meaningfully understand the role that Eurocentric scientific methods can and cannot play in their world? A logical reaction for this student is to reject Eurocentric science. These and countless other STEM curricular documents portray a combative tone that poorly relates to students in classrooms. Rather, we can approach the nature of STEM in a manner that integrates Feyerabend's thinking: we must carefully consider the nature of the problem and the ways of knowing most appropriate to engage with it.

Structural Shortcomings

We realize that a stronger curriculum is nothing without structures in place for students to experience it. A well understood issue in STEM education is the differential opportunities presented for students to experience quality STEM instruction and this can be viewed from a variety of perspectives: we have the differential opportunity gap between white and BIPOC students, the tracked classrooms that separate high quality instruction from mediocre environments with poor learning outcomes, and the differential curricular experiences between social classes. Education research broader than STEM reveals these structural issues and some of these are increasingly being paid mind by the STEM education community.

Milner's (2012, 2013) description of the opportunity gap points to the structural divide causing students to experience differential outcomes that occur along race and ethnicity lines, with BIPOC students receiving far lesser quality instruction. He writes of the opportunity gap that includes classrooms and schools with colorblindness, low expectations, and deficit mindsets. On the latter he states:

> I have learned that educators' conceptions and beliefs that lead to low expectations and deficit mindsets may materialize out of (a) conversations they have had among and between themselves about students perhaps in a Milner 707 teacher's lounge, (b) their interpretations of student results on standardized tests—sometimes even before they have met the student, (c) historical perceptions they have developed from their families about particular groups of students, or (d) isolated negative experiences educators have had with particular groups of people. Regardless of the source, such deficit mindsets and low expectations can be transferred into instructional designs and practices and can prove detrimental to student academic and social success. Due to a deficit mindset, educators sometimes believe they are actually doing students a favor by not developing challenging learning opportunities. These lowered expectations emerge in how and what they teach, and unchallenging content is often irrelevant and unresponsive to students' lives, experiences, and needs. For example, educators may not give students opportunities to engage in critical thinking, or they may fail to design a learning environment where students can be creative or offer views that differ from a teacher's or a textbook's explanations. (Milner, 2012, p. 706-707)

Within schools, Oakes (1985) denotes the structural issue of tracking that prevents significant opportunities to learn for those in the lower track. She describes a look and feel to the lower and higher tracked classrooms with stark relief: lower tracked classrooms emphasize discipline whereas higher tracked classrooms have more time on task. Lower tracked classrooms had poor teacher-student relationships whereas in higher tracked classrooms teachers present as mentors with purpose and intention.

And finally, Anyon (1980) depicts how higher social class students receive high quality instruction leading towards independent and critical thinking, whereas working class students develop an obedience to authority and limited opportunities for reasoning and problem solving. In the school attended by students whose parents are affluent professionals (doctors and lawyers), elementary teachers describe their science goals as follows: "It's [a very good curriculum] because it gives hands-on experience—so they can make *sense* out of it. It doesn't matter whether it [what they find] is right or wrong. I bring them together and there's value in discussing their ideas" (p. 82). However, in the school attended by the children of the working class, "the class had a science period several times a week. On the three occasions observed, the children were not called upon to set up experiments or to give explanations for facts or concepts. Rather, on each occasion the teacher told them in his own words what the book said" (p. 75).

The lack of access to high quality mathematics and STEM instruction has been discussed significantly in the STEM education research community as well. Moses and Cobb (2001) expose the deficiencies in mathematics instruction and through the Algebra Project provide a model for high-quality, culturally relevant mathematics education for BIPOC and lower socioeconomic students. Specific to high quality instruction for all learners regardless of track, although Oakes detracking research has been known for over 35 years, it has taken organizations like the National Council of Teachers of Mathematics (NCTM) until recently to officially state opposition to tracking in mathematics classrooms. As such, the practice in place in most US public schools is heavily fraught with tracking for all STEM classes in which high quality science and mathematics curriculum is experienced only by a small fraction of the student population. Certainly, actions like NCTM's detracking position are steps towards making this happen.

Specifying changes for STEM education

Given the discussion of the status quo, we have the exact changes specified below as steps towards a populace that can engage STEM concepts and social problems better than they are doing so today. These correspond directly to the curricular and structural changes outlined in the previous section. Afterwards, we spend a moment discussing the process by which these changes could occur but for the time being will leave these to the efforts of policy discussions in another setting. Returning to the controversial position taken by anti-vaxers as an example, we want to make it clear that while we are critical of the dominance of Western Industrial assumptions and applications of science we are by no means advocating against scientific inquiry, the scientific method, and most importantly scientific consensus. The key here is the ethical and political responsibility of anyone in STEM to asking the questions of "who, or what, benefits and who, or what, suffers unjustly?" We are arguing for a STEM education that focuses not only on the content learning but also the political contexts, implications, and responsibilities that a critical STEM literacy offers toward socially-just and sustainable democratic communities. While critical STEM educators and researchers are arguing for more social justice and sustainability in STEM curriculum we are adding to that call the importance of critical STEM literacy for students learning to navigate and make decisions in an era of a massive amount of misinformation and pseudoscience. The anti-vax position, excluding people who are immune compromised and truly unable to receive the vaccination, are too often making their political decision based on evidence that is not scientific consensus. The same is also true for climate change deniers. Rather than taking issue with the individuals being misinformed we are as educators, teachers educators, and researchers taking action to ensure that future citizens are skilled and knowledgeable in regard to a more critical and ethical STEM literacy.

For a populace that better engages STEM content toward preparing the type of decision-makers in a Democracy that are skilled and practiced in addressing 21st century challenges, such as global pandemics and climate change in connection with combating Racism, sexism, and other social injustice, we outline the following kinds of changes we are suggesting occur within US public school classrooms by 2030: First, all students experience a high-quality STEM curriculum that engages them in the importance of STEM literacy in making decisions that support diversity, social justice, and sustainability. Thus, following our sociological thought experimentation a STEM Education centered on 21st century decision-making in socially just and sustainable democracies first ought to include the following:

a. a student's geography, race/ethnicity, ability, sexuality, gender or class background should should no longer determine the school that they attend; and

b. all tracking and culturally-biased standardized assessment practices and outdated standards within schools are eliminated.

c. furthermore, teacher educators prepare STEM educators to no longer fall into the trap that STEM content learning can be taught a-politically and we engage in teaching our teachers to teach STEM content together with examples for how such content literacy and proficiency contributes to every-day decision-making through the importance of STEM Literacy to a healthy democracy.

Second, the STEM curriculum ought to be improved by:

a. integrating STEM content with social issues, both historical and current, as much as possible in all grade levels and

b. presenting a Feyerabendian approach, one inclusive of diverse knowledges to include Indigenous Knowledges, to philosophies of STEM that positions diversity and diverse ways of knowing as complementary to STEM ways of knowing.

For commentary and further illumination, we describe in more detail how these suggested changes will address the shortcomings in current STEM education both in structure and curriculum. In terms of curriculum, textbooks, curricular documents, and teaching practices will replace discussions of pseudoscience and the myth of neutral mathematics with honest examples that portray STEM knowledges as appropriate approaches for real-world problems that include abolition work, feminist teaching, environmental justice, and other social dilemmas our students are facing in the present and their coming futures. These will also provide historical examples of STEM decisions gone bad as well as when STEM decisions contributed to addressing a societal issue. For example, teaching about Tuskegee as an example of racism in STEM and the Human Genome Project to portray that STEM should be carefully and thoughtfully scrutinized for best practice and can be incredibly helpful to debunking socially constructed injustices like racism. Although some may think that this will embolden anti-science discourses, our perspective suggests that the superiority that science currently enjoys lends itself to more rejection than acceptance. Complementing students' and cultures' ways of knowing with STEM knowledges in a less combative manner will foster more trust and understanding. A supremacy of STEM lends itself to elitism, just as seen in the many vaccine refusals and hesitancies in the COVID era. Similarly, a STEM curriculum that forcefully rejects a STEM split with humanities and social sciences will serve to open up the space to learn about STEM's role, both good and bad, in social issues over time, such as those discussed in the previous section (the Tuskegee experiment and Morton's racism). A critical conception of STEM, similar to Skovsmose's critical conception of mathematics, will move the populace in a better direction to utilize STEM to solve 21st century problems.

Returning to the sociological thought experiment, imagine that the public education system has resolved these deficiencies in STEM education immediately in the year 2022. We as a world community that values diversity and decentralized democracies rooted in social justice and sustainability, are no longer swayed politically by false equivalencies and we have learned to navigate information valuing consensus from experts. This of course does not mean we ignore divergent ideas or efforts from scientists with counter examples. It means that we value the process of consensus and listen to all voices on matter but do not fall into the trap that a few differing outcomes are equivalent to consensus. Now this does mean that consensus decision-making is rooted in human rights (preferably social justice) *and* sustainability. Given some baseline foundations rooted in a democratic common good we set forth with goals of a STEM education aimed at a kind of critical scientific literacy that prepares citizens to value scientific consensus, to recognize outlying findings but to entrust the scientific community to continue to learn from those outlying findings and work ethically to inform our societies with information that is vetted by and supported across a diverse scientific community committed to the aforementioned democracy. This does not mean that scientists are never incorrect it just places the democratic value of trust in the peer review process and a social contract between citizens and scientists to uphold that misinformation is deadly to not only diverse lives but to democracy. When scientists are wrong, and yes it happens, the process of scientific consensus outs these errors through a research process of replicating studies and continued research to seek the best possible information in the interest of valuing peer review and democratic values and not basing finding to consider solely for the expansion of markets or any the authority of one single cultural set of values and ideals. Certainly, all research is political—and that includes scientific research; however, scientific consensus allows for diverse cultural representation and views to contribute to the process and then out of deliberation, review, and sharing of such findings by diverse experts the information called scientific consensus emerges for the larger citizenry to consider in making decisions. What is dangerous is when misinformation is given equivalent value in the decision-making. Avoiding the trappings or manipulations of false equivalencies is a survival imperative. Learning to both be scientists that value scientific consensus and democracy is as important as learning to be citizens who learn to be literate of the importance of information that clears scientific consensus. We imagine a STEM education that prepares such a scientific community and citizenry.

We assume that the effects of these shifts will not be apparent until youth complete this new version of the 13-year educational system in its entirety. Thus, we will not see significant changes until the year 2035. In that year, graduates of public K-12 education systems will enter the world as adults with STEM content that will be quite different from their predecessors. First, given the resolution of structural problems limiting access to critical and high quality STEM education, all 18 year olds regardless of geography, language, race, social class, or gender will have had the opportunity to learn STEM content. Second, this content will have engaged significantly with social studies topics to reveal the ways that STEM can help solve society's most pressing problems. Additionally through their studies, adults will understand that STEM can be harmful when left only in elite hands, and that STEM is only useful when it serves the people and has direct oversight by the people. Their STEM literacies will be an asset in the social project. They will also have significant experience relating STEM material to their own ways of knowing, including religious understandings, that negate any feelings that STEM conflicts with their cultures, ways of being, and belief systems. As a project for the people, STEM will not continue as an elite project.

Imagine, and our advanced apologies in suggesting this, that in the year 2035 a new pandemic arises or like in the recent film "Don't Look Up" an approaching comet is headed for Earth. This pandemic causes an illness not seen before and requiring STEM professionals to act quickly in developing protections against its spread. Or like in McKay's (2021) film, scientific consensus is that we need to act together and fast as a world community to listen to consensus and stop the approaching comet. The overwhelming majority of the adult population, now the products of an improved public education system, demand we value scientific consensuses for all methods to combat the pandemic or stop a comet. These STEM educated citizens pay close attention to each development and listen carefully to STEM professionals working diligently on behalf of society and the people. Rather than accept STEM elite's pronouncements, they demand public disclosures of progress made and why choices and decisions are made valuing consensus. There is no misinformation stoking fires of public distrust of scientists themselves but there are thoughtful concerns and public adjudication of what course is best to proceed. The people realize the importance of using the best of STEM, a scientific community that values diversity with Indigenous and all knowledges, to work collectively rather than to think individually, and as such, weigh in together on how STEM might work to mitigate the overall effects of the pandemic or things the problems of the present like climate change, racism, sexism, and eroding democracies.

And finally, imagine that in a world of diverse democracies like we have shared here—a world that for the most part have abolished many of the human rights issues we currently struggle to address. Imaging that the STEM solution for any crises like a new pandemic of 2035 lies in the invention of a new vaccine or in a cultural change of habits. It is approved for widespread use in 2036. There is no mass hesitancy. There is no ill-informed refusal. Social life and personal freedom, free from the worries and constraints of disease, resumes in mere months with minimal damage to communities, economies, and environments.

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