

Chapter 4

A Critical Pedagogy for STEM Education

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Freedom is acquired by conquest not by gift.

Paulo Freire

Abstract This chapter was first published in JASTE 2.1 2010 as a review of recent work in neo-liberalism and science education as they relate to critical social analysis. At the time I took the position that under neo-liberalism, education in general and science, technology, engineering and math in education in particular press the energies of teachers toward the production of workers, the everyday tools for the expansion of empires, a police state and war machine. A radical departure from the stricture of academic journal writing I wrote the paper to reflect my critical voice as I consider alternative pedagogies for the development of STEM education. A fusion of narrative inquiry, critical social theory and free writing, this chapter provides an update and revision of the original paper.

Keywords Neo-liberalism • Critical pedagogy • Science, technology and activism in education • Neo-liberalism and education

Introduction

This chapter provides a summary of a critical study of an alternative to Science, Technology, Engineering and Mathematics (STEM) education and a fusion of critical theory/pedagogy and political economy.

According to the neoliberal agenda, everything and everyone is for sale. Capitalism is an unfettered tool by which entrepreneurial corporate partners act on the global

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market, laying waste to government regulation and state-run businesses while ensuring corporations reap the benefits of patent laws and tax reform (Rodriguez and McLaren 2014). Neoliberalism run-amok is the global poor, the disenfranchised sold on the open market; capitalism is an upwardly mobile neighbor we can rely on to share with us the scraps of their table. While the world's rich parade round the world's beaches, major cities, amusement parks and centers of commerce, they take pride in their purchasing power. Adorned with the latest fashion trends, they hit the golf courses in Thailand, Vietnam and Mexico and, as night falls, descend on the night clubs and brothels exchanging their dollars for a few moments with the young women and men, castoffs of factories that supply the seeds for global wealth.

War, famine and disease have throughout history been the end-run of human experience, yet what science is available to relieve largely-social problems, instead, ensures the dollar is protected while corporations extract the living essence from the global ecology. Capitalism is the quantification of human beings; we are reduced to units of labor that provide surplus value: 15 min of our time mines the world for her resources, produces the printed page, the Gucci™ handbag, Macanudo™ cigars, or smiles on the faces of sex club aficionados.

According to Lacan (2006), we desire all that shines as long as what shines continues to shine: the social meme relating to an original thought, idea or experience. What can we say is an original thought, idea or experience? Since most of our becoming has to do with the people, places and histories with which we are surrounded. Take a person, change the place across space and time; will (s)he be an astronaut, a surgeon, a cleric, a suicide bomber or a freedom fighter? Will (s)he be one of these or all of these? We become the ideas we are given: our ethnicity, social class, gender and sexuality are social tags fixed by the other; “they” determine the course of our living experience and the value of our lives.

The critical experience that is the day-to-day of the classroom, the boardroom, and the playground is you and I sold on the idea our living has exchange value. From the pacifier soothing us to sleep to the car we are awarded at high school graduation, we determine the course of our lives based on what we are willing to sell: your spine, your mind and your sexuality will accept or not accept the world as it is. What was it Marx said? Spaces and places are fields for the production of someone else's knowledge, wealth or phobia (Bowles and Gintis 1976). Karel Kosik (1976) understood, society's eyes of experience, the pseudo-concrete and the pseudo-intellectual, what we know or think we know about our experiences with the world and each other. Does all of this sound esoteric? Sure. But that is part of the design, at least the education made possible under capital.

Global Capitalism

According to Dave Hill (2004), there are five major trends in Global Capitalism: (1) Spread of capitalism both geographically throughout the states of the world and sectorally within those states; (2) Deepening of capitalist social relations with the

commodification of everyday life; (3) Increasing use of repressing economic, legal, military, and other state and multi-state apparatuses globally and within states; (4) Increasing use of ideological state apparatuses in the media and education systems; and, (5) Increasing concentration of wealth and power (power to retain and increase wealth) in the hands of the capitalist class.

Echoing this position, Henry Giroux's (2009) analysis of the project of neo-liberalism is pervasiveness evident on its influence globally and on the restructuring of social life. This is restructuring social life to support the interests of capitalists, the cementing of capitalist social relations of production manifested across the known world. The stranglehold on the planet by global industrialists is no-thing and no-body escapes the path of capitalist expansion or consumption. Have a look at the major tourist attractions where children and adults hawk the latest cultural artifacts, artifacts purportedly crafted by local people. Upon closer inspection, their labels prove pieces you can buy at the pyramids in Egypt, Mexico or Guatemala are made in Thailand, India or China. Moreover, children and adults on the streets spend their days collecting, sorting and selling, they experience the capitalist dream they in turn, were sold; the more they sell, the more they sell. Put another way, 100 key-chains sold to tourists will buy a sack of rice, a bag of beans or a bowlful of chickpeas. Fifteen hours on the street or 15 min on your back will ensure you can buy medicines, clothes for your family or food.

Capitalists and capitalism operate under the assumption that if you starve a person enough while offering them a way out of misery, climb the social ladder, produce/sell enough key-chains, while avoiding revolution, you will have arrived at a self-perpetuating system. The minutiae of capital are avoided, the sequence and the outcome are not as necessary as the systems [apparatus] in place to ensure success. It is important to note here the fruits of capital are mere specters; the end goal of capital is the perpetuation and maintenance of the system. People do not continue under ideological slavery because of the rewards set before them: they act upon the idea the reward that is capital buys freedom.

Under such a system, one must wonder what of the price of an education? Can we say it is worth a thousand key-chains, two thousand or ten thousand? And what of the labor power traded along the human chain from the hands that produced the item to the hands that consumed the item. Global Neo-liberalism has many caught on the human chain, from inception of an idea, genesis of a product, to conception of the fruits of capital [surplus value]. How we arrive at the nexus of production is paradoxical. Why do humans continue to believe they can buy their way through life?

STEM and Activism in Education

According to the Congressional Research Service (CRS) report, 2006 and the America Competes Act 2008, US pupils fail to reach adequate levels of proficiency in the STEM disciplines. A lack of performance in the STEM disciplines much as in Literacy education, is reduced to: teacher quality, funding by the federal government and a comparison of data, how the US currently fares compared to

other countries. The data disaggregated across K-16 education describes the structure of STEM education in the US and abroad while failing to detail the obvious: the relationship between STEM curricula or programs and student scores.

That students fail to make adequate yearly progress (AYP) is designed into the system of public education. Teachers and administrators are made to adopt a technicist view of science and math curricula. Theory and Method are taught according to the latest and historical school of thought: teachers deposit information, information students then regurgitate during testing at year's end. Diverse methodologies for arriving at solutions or creating/transforming a theory, existing research or paradigm are ignored since the outcome of failing to make AYP is government takeover of public schools and school restructuring. STEM education in the United States is reduced to the memory, and methods fetish (Macedo 2006). Students are taught the appropriate theory, method and test taking strategies, including the correct operations and answers. The preceding must sound familiar, a simple analysis I conducted using personal experience mentoring new and current teachers in US public schools, the latest headlines concerning school takeover and Horace Mann's The Republic and the School, although we could include Dewey's Experience and Education. The basic principles are: create curriculum research supporting policy, legislate the curriculum, tie policy to research and funding, mandate the conduct of schools. The states then toe the line as Capital involves one of two options: take the Billions or be sanctioned.

What is education then in US Public schools? A process of indoctrination and an assumption by the elite that values, principles adopted by the masses will ensure their good conduct. This is what Henry Giroux calls the hidden curriculum or the interplay of ideology and action (1997, 2001) these are the limitations on the unconscious, common sense and critical consciousness meeting agency and the individual. As students are taught in US public schools the years of penal indoctrination and assimilation take hold; we are taught there is a right answer for everything, stray from the path and you will not receive your pot of gold. Educational policy, the America Competes Act, No Child Left Behind or Race to The top, creates institutional thinking among the masses, students, teachers and families; STEM education much as Literacy education becomes a further encroachment by government on the individual (Durkheim 1984). In US public schools, we are taught to accept the status quo for the sake of society, America or as is ever popular we do it "for the children."

STEM Education, Research and Practice

A land of rigorous abstraction, empty of all familiar landmarks, is certainly not easy to get around in. But it offers compensations in the form of new freedom of movement and offering fresh vistas. The intensified formalization of mathematics emancipated people's minds from the restrictions that the customary interpretation of expressions placed on the construction of novel systems of postulates. New kinds of algebras and geometries were developed which marked significant departures from the mathematics of tradition. (Nagel and Newman 2001, p. 12)

K-12 schools, colleges and universities are more than mere purveyors of information or empirical paradigm (Rodriguez 2008). Students and professors engaged in the practice of teaching and learning do more than argue quanta, the lifespan of a mud-wasp or the credibility of one form of analysis over another in describing the day-to-day experiences of humanity.

We are engaged in our individual practice as we set out to discover/uncover phenomena and processes related to the understanding of all life, objects or ideas. In writing this chapter, I support the existing knowledge in the study of science education, science and technology studies in general and the study of activism in science and technology studies (STS) in education in particular. This is by no means a comprehensive view of the field; instead, it is an interest held by myself in the development of a personal critical revolutionary praxis and, more importantly, standing in solidarity of pedagogies that are progressive, activism-oriented and that seek to promote the critical revolutionary project.

Not a new field nor a new practice, the study of science and technology in education has enjoyed and been conflicted with a similar past as that of language and literacy studies and the urban and social studies in education. The traditional paradigm holds to the Cartesian understanding or engagement of phenomena. What can we surmise about distinctions made among objects, ideas or fields of experience? What can we understand, moreover, to manipulate those fields to the benefit of the individual and society and, more critically put, the employer, the license holder (trademark or copyright) and the individual?

The work of Wolff-Michael Roth provides a progressive look at the traditional forms of the study of science, science education and the study of science and technology in education. In his work from the 1990's, he submits constructivist understandings for the teaching of science and technology. Similarly, Lawrence Bencze, Stephen Alsop and Angela Calabrese Barton add to the existing literature in science in education studies and the constructivist and progressive research and teaching paradigms. In *From Everyday Science to Science Education*, Wolff-Michael Roth submits the notion that science and technology in education can offer the student much more than a clinical understanding of ideas, arguments or phenomena. Education in the pedagogy of sciences operates under the traditional assumption that students are objects to be filled with the diversity of data and methodology that governs the field misunderstood as the scientific method (Roth 1997). Furthermore, he describes what we have seen across other disciplines. Schools, colleges and universities act as gatekeepers; who passes the class, final exam and submits for the degree or diploma are eventually who practices physics, microbiology or engineering in the field.

This understanding of the disciplines, knowledge adopted from the school or the classroom community, enacted and engaged in the field, is contrary to the practice known by philosophers and theorists about being in the world and enacting a chosen profession, vocation or other way of being in the society. Experience, reflection and further practice in a relationship with peers and the natural environment provides an individual with the empirical knowledge to carry out a profession, vocation or other way of being in a society. Knowledge of phenomena in nature or a social experience

is affected by history and the social relationships that contribute to the development of knowledge in a given cause or relation among objects or experiences.

That is to say, if we demonstrate the physical properties made by the upward and downward movement of a yo-yo to a student (Roth 1997) but do not push beyond asking students to consider why a yo-yo swings up and down when a person plays with a yo-yo, we can expect that students will provide a pat answer; e.g., ‘Yo-yos are affected by gravity or they spin held by a string depending on the amount of friction acting on the central pin as it rotates.’ The preceding is perhaps important for the understanding of gravity and friction. But what of the cognitive demands for the creation of string, the plastics and bearings involved for professional yo-yos? Pushing further: why use plastic for the creation of toys instead of wood?

A Critical Pedagogy for STEM Education

The birth of critical pedagogy is the historical fusion of many traditions of inquiry. They include existentialism, Marxism, the critical theories and feminism among others. Critical pedagogy differs radically from traditional forms of education in that pedagogues seek to develop with their students a transformative posture where student and teacher make sense of their lives while challenging the dominant and authoritarian ideologies in schools (Giroux 1997). The focus of critical pedagogues is the auto-emancipation or what Freire calls the re-humanization of their students (1970). What I mean is under Capital education or schooling operates under the construct of human enslavement vis a vis the cementing of social relations of production across the lifespan. The end-game of the dominant class is the classification of students and their acceptance as workers across the strata that are societies.

Constructivism, activism and STS-like critical pedagogy across the disciplines do not assume that students are empty vessels to be filled with factoid about social relations or the natural environment (Freire 1970). Instead, they provide a framework or grounding in knowledge that supports personal critical analyses of distinct phenomena. Why do we want to know about people, or people and their relationships to yo-yos? What I mean is yo-yos, like atom bombs, are interesting subjects, they can be related to a personal experience, but what is the end result of the use of yo-yos or the atom bomb in the world? It is the above idea I wish to continue discussing as analyses of the efficacy of curriculum design in teaching and learning affects teaching and learning outcomes. Teachers, Roth (1997) describes, are more accurately represented in the constructivist paradigm as more knowledgeable old-timers who engage with students in pedagogy where the material and discursive relations are interrogated such that the teacher is an authority figure. The act of teaching similarly related by Freire (1998) is to embark in teaching and learning with students to share information, working with students to uncover the static and dynamic properties of distinct objects or human relationships.

Teachers, instructors and professors then must set the conditions for learning to occur (McLaren 2007). In science education and STS, Roth and McGinn (1998) and

Roth (1997) describe these conditions as the authentic relationships engaged by teachers and students and students and the world situated in ways that reflect the complexity of processes and operations that scientists and other practitioners in the field experience. These are, as Roth and (1997) others describe, authentic learning tasks and authentic environments. Students must not merely mimic experiences from the field but actually undertake figuring, working with and refiguring a problem. They can then reflect on data and experience conducting research to ascertain a series of analyses that might provide a viable solution to the science implemented in the field.

The outcome of such practice is the student-led inquiry process. No longer dependent on their teacher, or codependent as they act out their respective roles, the student with the conditions set for learning embarks on the quest for knowledge by working with ideas from inception of the problem [what do we observe in or about nature?] to developing a research project: choosing the subject to be studied, how it is to be studied and which if any outcomes will influence the field and contribute to the further development of ideas or a research paradigm.

Community and Revolution

I sought a graduate degree as a way of understanding the social relations that overtly and covertly contribute to how and what my students learned. At graduate school I became more familiar with the progressive and critical tradition. The academic experience has been a journey marked by teaching, learning and writing about what Hannah Arendt (1959) refers to as the human condition. That is the complex social relations that happen, at least on this planet, in developing the fullness of humanity. It is my position in engaging the professoriate, teaching profession or instructorship to engage theory beyond dialogue. Sitting at the armchair of freedom, progressive liberals and radicals alike might argue the benefits of liberatory education over constructivist thinking in the schooling experience. They might decry the need for a closer inspection of the functions of US democracies and neo-liberal global capitalism; and yet, still not arrive at the crux of auto-emancipation.

The depth of consciousness necessary to take a critical and collective moral posture in acting on instead of simply knowing about the world: war in the Sudan or Iraq and Afghanistan or the return of the dust bowls to the Sacramento/San Joaquin river valleys and the parchment of the Sub-Saharan African plain.

Theoretical Freestyle

Democracy as currently understood lends itself to a blanket understanding of all a capitalist cabal wishes it to be, history is dead. More aptly put, perhaps, capital wishes history to be killed every day as Wal-Mart profiteering in the form of small town monopolies glutted with family owned business bankruptcies and tent cities

spring up in the wake of the mortgage and real estate meltdown. So marks Lenin's understanding of imperialism, the social amnesia that self-converts human lives to human capital (McLaren 2007). Can democracy vanquish capitalism? Can the tip of the spear driven into the heart of global enslavement be marked by the blood of revolutionary liberals? Radicals doing more than sitting at armchairs idling days away with prospective to change the world and turn the tide of human traffic.

Bow-tie and elbow patches, pipe tobacco at the ready, the arm chair philosopher sings out the sound of democracy, crying havoc, ringing the liberty bell of freedom; while, at his white Christian feet, students fawn, grovel and lick up pearls of wisdom as they're spouted in the name of the epistemic tradition, to boldly know what no man has thought before. Truth at the feet of liberty congealing to break out in new ways to light a light bulb, cook a turkey, or impress the latest generation of hyper-consumers every Tuesday and Thursday at 7:00 p.m. sharp.

What are these cool kids singing for in their hipster dens in Brooklyn, Westwood, Palm Beach, and Signal Hill? When will my trust fund recover? Ask CNN, The New York Times or The Wall Street Journal; time and time again, they declare an end to the current state of capitalist affairs on the world stage. Yet what we have here is more akin to market control, the day after the Times and the Journal print a change in the market the market changes. Perhaps Gabriel Garcia Marquez was correct as he submitted his version of magical realism in reflecting social relations, what people believe to be true about foreigners and each other. Magical realism on the world market or a magician's trick, sleight of hand, as what the naked eye sees the mind believes.

The present condition of the United States of America: global capitalist hegemony; we are no longer asked but made to believe and act out in the everyday of our human experience (McLaren 2007). All social relationships are commodified, every chance meeting is an appropriate moment to network; who you know, what you know, and how can you manipulate the present social moment such that all moments from this one forward will be marked by hyper social capital and material consumption. Your success is marked by the Rollei™, Cartier™ and Benz's™ stacked in your drive-way. So the discursive relations of human experience go. The Journal describes an educated workforce as offering 'sub-prime human capital' while the Times signs off on the white house 'push' for an improvement in the teaching of science math and technology in United States schools.

Analytical Freestyle in Science Education

If the above resembles a rant, consider why a string of words that includes political and economic critique and the actual market functions of our global society affect the reader's view of this chapter. The academy turns its nose at work marginally reviewed or constructed as outcry, pedagogy of indignation (Freire 2004) at how people continue to enslave other people while destroying the last useable resources on the planet. Organic and academy taught intellectuals have given the world their

lives, their blood sweat and fears chasing the ether, the unifying principle or truth, to solve the worlds mysteries. And how are they repaid? They are distracted from their work by colleagues who scream bloody murder as they find ways to take solace from the everyday right wing never ending barrage.

Is it the argument they are after when they cry foul? Or is it the sign, the symbol of freedom represented by a life's work in the academy sharing the living experience with students, colleagues, all workers alike managing the living, the breathing and the dying. And what is capitalist schooling at its best marked by the alienating principal: fuck the guy that helped you graduate that ensured you made it to the next step, the next position on the research/career ladder. Was it truth we were after as we began our study in the hopes of shedding light on some obscure fact? The mating principles of the mud-wasp or sexuality in the human male, are these black holes in the minds eye as rebellion takes the place of cultural logic and cultural truth? So progressive educators a reflection of the reality that is human destroy the earth and its atmosphere when their pedagogy ensures children learn the science necessary to produce industrial coatings, fertilizer and cyanide without also ensuring they acquire the depth of consciousness necessary to make connections between wearing a gold and diamond ring and the use of cyanide and strip mining for their production.

Pushing still further, why is Marxism such a word of abuse (McLaren and Jaramillo 2009)? Even the right can see the fluidity of accepting the changing condition of the system, what Lacan (2006) refers to as *synthome* of societies. Radical pedagogy ain't for the timid, it is a critical revolutionary praxis marked by the blood of Zapatistas, Che Guevara, Hugo Chávez and progressive intellectuals that understand a need for change from gripping tight to the cosmic orgone (Reich 1973) that is Capital; it does not allow for any competing principal or ideology. The search for truth is not about finding the source of all energy or a catalyzing principal.

It is the understanding that humans and objects share relationships, principles that adhere to organizational value and metaphysical conception and oscillations. The gangrene of racism, sexism, fascism and homophobia are human made (McLaren and Jaramillo 2009); they are the legacy of the left and of the right. What can be done about them is marked by the way intellectuals enact and participate in their personal and social praxis. A critical reflexivity that draws the kite-string of principal between the market need to produce chemicals for consumption, like Zyklon B, and the necessary day-to-day Socratic discursive practices doing more than shouting out to father capital in the classroom.

Human and environmental devastation are the end result of our social relations (Rodriguez 2009), which includes the needs and whims of markets and of the hyper-complex systems that are societies as they trade in material and human surplus value. The legacy of Marx and critical analyses are not the mere Utopic visions of a few stalwart, yet antiquated, intellectuals (McLaren 2007). They are a cultural critique positioning trade consciousness and social amnesia as the culprits on the market stage of global capitalist domination. Critical social theory does not disclude what is or what the agent knows or has known, like the conglomerate it

promulgates all byproduct of human relations bad and good as actors that contribute to the enslavement of the individual and the devastation of the natural environment.

Dissemination, the symbol, the division of units and of labor, the structure of the phenomenon all bear as a derivative of the human and environmental condition of existence markings of each other. All symbols of experience return to the source; that is, we humans police ourselves and each other and we free ourselves and each other.

Closing Remarks

The global market occupies virtually every corner of the struggle for humanity (McLaren and Jaramillo 2007). Children in classrooms are the direct inheritors, as they grow to adulthood of the social and natural environment adults accept. War is class war, as those who reap the benefits, profit margins, on a global scale are never those with most at risk; the soldiers doing the killing in the fields benefit only so far as their use value is justified in controlling the world via the wholesale slaughter of ‘enemy combatants.’ These are children and adults in the so-called terrorist states who happen to be in the way of cementing capitalist social relations – whether copper, oil, timber or human interests. Furthermore, the human life span is far too short for any one human being to have an effect that significantly impacts the world market. We are far beyond the moment where the Molotov cocktail, the baton or a rock thrown by its self can cause the adoption among the human chain of a worldwide position for revolution. Even when riots occur, the 1960s, 1980s or 1990s, 2000s globally, the market fights individual citizens to a standstill. Hard to throw a rock when you are starving, or when you have to excavate rubble to recover and then bury your children. And yet the US has been successfully fought to a standstill, in the market by Cuba and Venezuela and at war by Afghanistan and Iraq. Why does a military that possesses the sole surviving global Air Force, Navy and Army continue to make war on people that return fire from horseback using muskets and single shot World War I era munitions? The war begun in 2003 was conceived over 10 years prior; in 2009, the US was still at war with, according to Gibson (2009), a military with no long history of defense no internal defense industry of note, no definable supply lines, no clear chain of command or central leadership. Can it be there is more to life and war than production or enslavement?

The classroom, as McLaren and Jaramillo (2009) relate and as Bencze and Alsop (2009) elaborate, were the last truly public domain where students and teachers could engage in a respite from the dominant ideology; to consider the social relations that exist and ways they affect the environment. According to David Hirsch (2006), “[n]eo-liberals’ desire not to intervene in markets and to focus on economic growth, primarily terms of consumption, has both significantly contributed to the environmental problems that we face and to global warming” (p. 5). The copper canyons in Utah were not put their by meteors, but by mining operations. The depletion of salmon and steelhead in the rivers and streams of California,

Oregon and Washington did not happen as a product of the ravages of time. Human constructed, petrochemicals, positions on the treatment of the environment as things existing solely for the purpose of providing the corporatocracy with surplus value created all of it.

Critical educators in and out of the classroom stand as a measure of change as the onslaught of neoliberalism continues. People cause the ravages of time to negatively affect the planet, surplus accumulation whether it is PCB's in the Hudson, ammonium nitrates at the mouths of the world's major rivers or the debris from surface and subsurface detonations of nuclear material. Yet there is another more insidious form of surplus accumulation with students in classrooms across the globe, the toll of curricula and pedagogies ensuring students leave classrooms functionally illiterate; capable only of reading and acting out the prescribed lives global capitalists have set. Human agency and enslavement result, as people live careless to the effect their actions have on the natural environment and each other. Critical pedagogues in the natural and social sciences do more than share information with their students. They leave a lasting imprint, a seed which may contribute to the production of knowledge. But, more importantly, offer an alternative to the living currently destroying the planet. Our outcome with students is, "a pedagogy, therefore, that can help students reconstruct the objective context of class struggle by examining the capitalist mode of production as a totality" (Allman et al. 2005). Critical pedagogy for STEM education then is working with students to link their human development and human potential with a collective global consciousness occurring outside of capital to resist the further infringement by the corporatocracy on their lives.

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