STEM History

Abstract

We live in a time of unprecedented change. Global science, technology, engineering, and mathematics (STEM) innovations abound. It is probably more important to study STEM history than it has ever been. But a study of inventions and shifts of Kuhnian paradigms are not enough; they risk being mere descriptions of history, without enough insight into the consciousness, and therefore, the motivations of our ancestors. Transformation occurs when the educational experience allows for critical examination of the diversity among peoples and between our current generations and our former ones. Education has created a great blind spot by projecting the modern left-brain consciousness onto earlier groups, denying a re-birth of our right-brain genius. Doing this, then trying to interpret the history is like analyzing a team's performances without having the playbook. Once the history of consciousness is overlaid onto STEM advances, we open students to the possibility of true future innovation.

Introduction

There is a serious mismatch for educators in the U.S. when we are trying to honor both history and also integrate science, technology, engineering, and mathematics (STEM). Although there may be many problems in this area, the focus of this paper is singular in that it addresses a lack of awareness that human consciousness has been changing over the ages and continues to change. What Kuhn (2004) describes so well as paradigm shifts in the human outlook on science still does not fully reveal the *pattern* of how consciousness has shifted over time. Therefore, this paper uses the evolution of consciousness as a backdrop to study the history of human invention and discovery. In particular, this paper makes a broad brushstroke of the evolution of consciousness, showing three main stages or versions as follows. Version 1 occurred ages ago when humankind learned in a transformational way that was predominately intuitive (or right-brain). Version 2 occurred as humans became agrarian, then industrial, transitioning to a predominately analytical (or left-brain) learning. Version 3 has just begun over the last two centuries. If version 3 continues to establish itself as firmly as versions 1 and 2, it will be the possible dawning of the balance of both intuitive and analytical learning (or right-brain in

harmony with left-brain thinking). In order to accomplish the purpose of this paper to create awareness that consciousness has been changing, this broad brushstroke will attempt to show that there are two major historical turning points: one where human consciousness began the shift from version 1 (intuitive, right-brain) to version 2 (analytic, left-brain), and one where we have possibly begun the shift from version 2 to version 3 (balance). Before beginning the historical trace of these shifts some terminology will be defined.

The Descriptors *Right-brain* versus *Left-brain*

The use of the terms 'right-brain' and 'left-brain' should be clarified. It should be noted that recent research on asymmetric lateralization of brain hemispheres has noted that purely physiological measurements from neuroimaging data does not provide clear evidence that dominant networks exist as a broad generalization. "Yet our analyses suggest that an individual brain is not 'leftbrained' or 'right-brained' as a global property, but that asymmetric lateralization is a property of individual nodes or local subnetworks, and that different aspects of the left-dominant network and right-dominant network may show relatively greater or lesser lateralization within an individual" (Nielsen, Anderson, Zielinski, Ferguson, & Lainhart, 2013, p. 8). For this paper, however, it will be noted that neuroimaging is restricted to physiological information, not the psychological occurrences in consciousness.

> It is important to note that our data measure only asymmetries in the magnitude of functional connectivity between homotopic connections, but do not measure differences in the content of cognitive information between analogous connections in opposite hemispheres. Thus, a connection in the left hemisphere could be associated with a completely novel neural computation from a homotopic connection in the right hemisphere yet show no difference in functional connectivity lateralization. Nevertheless, lateralized functional correlation suggests a network architecture that differs between the two hemispheres and may be an indicator of the content of the two networks given known differences in function of the respective left- and right-lateralized hubs. (Nielsen et al., 2013, pp. 9-10)

This paper will deal with the psychological as opposed to the physiological descriptions of consciousness in order to clearly speak of the definite distinctions in those behaviors and not be held back by the pairing of behaviors to physical events in the brain.

> The information from the EEG is instantaneous, and therefore quite precise in time, but harder to localise precisely in the brain. By contrast, functional magnetic resonance imaging (fMRI), the preferred method of imaging now available, gives more precise localisation, but with a three- to five-second time spread. These techniques can be combined. Neuroimaging, including single photon emission computed tomography (SPECT) and positron emission tomography (PET), as well as fMRI, use a variety of techniques to detect where there are changes in the perfusion (blood supply) of the brain, the common principle being that active areas metabolise at a higher rate and therefore require a temporarily increased blood supply. It is worth saying something, however, about the problems associated with neuroimaging studies as a source of information on their own. Imaging just shows a few peaks, where much of interest goes on elsewhere. One cannot assume that the areas that light up are those fundamentally responsible for the 'function' being imaged, or that areas that do not light up are not involved. And, what is more, one cannot even assume that whatever 'peaks' is of primary importance, since only effortful tasks tend to register – the more expert we are at something the less we will see brain activity. For example, people with higher IQs have lower cerebral metabolic rates during mentally active conditions; as do those with bigger brain size, which is also correlated with IQ. We have, too, to remember that the activations we visualise in the brain may actually be inhibitory in nature – inhibition may be indistinguishable from activation using current fMRI methods. (McGilchrist, 2009, Locations 971-986)

The psychological differences in consciousness that can be grouped under the terms: left-brain and right-brain traits that this paper will use are delineated below.

> Nietzsche held that 'in contrast to all those who are determined to derive the arts from a single principle, as the necessary source of life for every work of art, I have kept my gaze fixed on these two artistic deities of the Greeks, Apollo and Dionysos. According to Nietzsche, these two gods represented the two fundamentally opposed artistic drives (Kunsttriebe): one towards order, rationality, clarity, the sort of beauty that comes with perfection, human control of nature, and the celebration of masks, representations or appearances; the other towards intuition, the over-riding of all humanly contrived boundaries, a sense of oneness or wholeness, physical pleasure and pain, and the celebration of nature beyond human control, as she really is. It will be appreciated that this contrast does not correspond neatly to the left hemisphere versus the right hemisphere – more, in neuropsychological terms, to the frontal lobes versus the more ancient, subcortical regions of the limbic system; but since, as I have emphasised, such distinctions carry with them implications for the division of the hemispheres (in that the right hemisphere is more in touch with these ancient and 'primitive' forces, though

> modulating them importantly in many respects), they have a relevance to the subject of this book. (McGilchrist, 2009, Locations 5344-5353)

The History of Consciousness as seen through STEM Advances

"Transformation theory holds that our acquired frames of reference and the beliefs and values that they endorse may be transformed through critical reflection on one's assumptions and the resulting interpretations validated through discourse" (Mezirow, 1996, p. 237). The individual's learning process is not only aided by entering into dialogue with a group, but also through relational aspects by: receiving encouragement, scaffolding, and increasing self-efficacy from the group. Learning in circles, a type of learning that claims to transform character is achieved by meandering through ideas where a circle of individuals think as if they were one person, according to Asante (King & American Educational Research Association. Commission on Research in Black, 2005). Mezirow builds on the idea of transformation of the interaction that aligns more with right-brain, intuitive, relational activities. An historical backdrop for the pedagogy in which early African society situated its first educational institutions reveals highly intuitive approaches that parallel the way both Mezirow and Asante re-connect to the ancient ways.

As part of the study of consciousness one must consider factors that affect learning. Some early evidence of the learning process lies in the study of the origins of civilizations (Diop, 1974; Houston, 2007; Stone, 1976). Parallels can be drawn between the social and cognitive development of the child and the early development that many civilizations go through. While earlier literature has dealt more with the inter-relationship of the social, emotional, and consciousness factors that affect learning in the first stages of childhood (Asante, 1991; Diop, 1974; Gaskill & Redgrave, 2007; Graves, 1875; Houston, 2007; Loewen, 1995; Ptahhotep,

Kagemna, Gunn, & Amenemhet, 1985; Stone, 1976; Teresi, 2003), recent studies have begun the process ways that "teachers need to go from fearing STEM to playing with it and venture to integrate STEM into their classroom" (Torres-Crespo, 2014, p. 14). But, the current state of pedagogy in the teaching of STEM from the primary level to high school often is satisfied with a basic introduction of hands on science experiments, engineering of household objects, and computer technology. This paper will recommend that the integration of STEM into the classroom needs to accompany the training of the right brain. It needs to show students how they should stay in a state of observation (right), attending wholly to a phenomenon (right), before jumping to an analytical conclusion (left). It must undo our modern tendency to get right answers, name things, and quickly move away from the wonder and beauty and nature of a waterfall to the mechanical uses of the water's power and the physical operation of it.

An exercise I often use in STEM classes is to show a series of single line statements and ask which are observations and which are analyses. For example, one statement might be, "Bubbles are forming in the pot with flame under it." An accompanying statement might be, "The water is boiling." The first is pure observation, whereas the second requires an analytic thought process based on an observation. I show how one must exclude numerous possibilities to jump to the conclusion that the water is boiling. Although it may be a good conclusion, the act of analyzing and forming a conclusion, by definition, must narrow many possible explanations into one. Could the water have released trapped gas before boiling? Could the liquid be something other than water? Could the flame be burning a substance that remains fairly cold while burning? I perform such exercises throughout every course I have ever taught. I make social justice links to the act of jumping to conclusions about people and relationships. The key is always to go ahead with the act of analyzing and concluding; it is how we invent new technology and new

ways to work with the world. But, in making conclusions, I stress that we should always try to remember the pure observations from which they all sprung. The unanalyzed observation always has in it more to tell us. There is always more than met the eye, no matter how many times we look. As children we progressed from the unadulterated ability to be captive to bubbling water in a state of pure observation, to the more complex thinker who sometimes loses child-like wonder and awe in favor of reason. So, this paper then, will map the social history of consciousness onto the social / cognitive development of the child. The reason for this connection lies in the argument that consciousness changes in fluid stages. And the stages of the development of the consciousness of the child tend to follow the pattern of the stages of various civilizations.

First, I will examine the specific stage of development when a child shifts from a consciousness that is able to comprehend the world in its intrinsic wholeness, but is not able to break up those wholes, nor analyze abstractions, to the stage where analysis and reason takes over and the child begins to lose the ability to grasp whole ideas in the same manner as before. I will connect the definition of consciousness from Sylvia Wynter, that will be used in this paper, as our "subjective experience, including that of our subjectively experienced modes of identity" (Wynter, 2001, p. 4) to the idea that this consciousness may not be caused by our physical, biological, neural processes – but simply correlates to them. I will use evidence from ancient writings, that humankind relied upon, that were received intuitively (Bandura, 1971; Carroll & Tober, 1999; Gardner, 1993, 2008; Glazer et al., 1999; Goleman & Boutsikaris, 2006; Goleman & Senge, 2007; Goleman & Whitener, 2005; Kuhlewind, 2004; Mezirow, 1996; Miller, 2005; Palmer, 1993, 1998, 2004; Palmer et al., 2010; Papert, 1980; Piaget, 1950; J. Piaget & B. r. Inhelder, 1969; Portes & Salas, 2011; Quinn, 1992; Senge & Barker, 2008; L. Vygotsky, 1979; Lev Vygotsky, 2002; Wertsch, 1985). And so, to serve the purpose of the paper, I will propose

that if our changing consciousness is not necessarily biologically driven, then perhaps shifts in consciousness are not. And therefore, if both early childhood and early humankind used to think in wholes – a different subjective experience, or consciousness, then perhaps children are receiving whole ideas intuitively. And if these intuitive acts did in fact represent a valid subjective experience to our ancestors and our childhood stages, perhaps this form of thinking can cycle around to be accessible to us now. In other words, ongoing evolution of consciousness may make the recovery of intuitive powers possible without the surrendering of analytical ones. I will further venture that certain academic disciplines like quantum physics can only be comprehended by a consciousness that can hold intuitive right-brain ideas when used in concert with the analytical left-brain ideas. One implication that is relevant to STEM teaching can therefore be made clear at this point. Understanding of phenomena such as: electromagnetic induction, epigenetics, observer effect, evolution, entanglement, or complementarity are enhanced by the ability to think in whole ideas - a consciousness that can be studied either by an historical study of ancient humankind or a study of early childhood stages of learning.

Even though educational research has an intense interest in the learning process and despite the fact that it recognizes that there is a parallel in human cognitive developmental stages to the historical development of the consciousness of humankind as a whole, there remains a gap in the scientific treatment of the psychological characteristics of consciousness as it relates to the learning process. “The question of the psychological nature of consciousness is persistently and deliberately avoided in our scientific literature” (L. Vygotsky, 1979). In this paper I define consciousness according to the research of the last quarter century, then I review the literature for major psychological characteristics of consciousness as it relates to educational theory and the

learning process. I conclude with a prescription for educational reform that calls for a curricular difference in the teaching of history and STEM subjects.

Defining Consciousness

To define consciousness is an extremely difficult task because it involves the observation of thoughts either through the use of other thoughts or through the use of some ability to observe thoughts, that is itself not comprised of thoughts (Piaget, 1950). Recent studies to come out of MIT are introducing a wide range of definitions of consciousness. At one extreme is a strictly physical interpretation of consciousness that believes in "the neurochemical and neurodynamical basis of both emotion and consciousness. The central capacities of the mind, no less than the peripheral, have been addressed with systematic profit by various materialist research programs" (Churchland, 2013, Locations 497-498). In defending this belief, Churchland cites that the three independently revealed trees produced by Darwin's body-similarity analysis, the developmental tree in the fossil record, and the genomic analysis tree. Churchill therefore concludes that "Arguments like these have moved most (but not entirely all) of the professional community to embrace some form of materialism" (Churchland, 2013, Locations 544-545). But there are counter arguments that believe consciousness has a non-physical basis.

> A general definition of consciousness requires that most views and the contexts in which the notion of consciousness is used should be included in the definition. In a general definition as mentioned above, consciousness is a mental aspect of an entity (system or process), which is a conscious experience, a conscious function, or both, depending on contexts and particular biases (e.g., metaphysical assumptions). This definition tries to accommodate most metaphysical assumptions. If the dominating view is materialist or functionalist, then consciousness is likely to be considered as conscious function. If the dominating view is dualist or idealist, consciousness is more likely to be considered in terms of conscious experience. If the dominating view is dual-aspect, panpsychist, panprotopsychist, panexperientialist or panprotoexperientialist, consciousness is likely to be considered as both conscious experience and conscious function. (Vimal, 2010, p. 110)

It is important for this paper that the definition of consciousness remain open to the possibility of non-physical, conscious experience. Otherwise, if a strictly materialistic view is adopted, the basis for *intuition* might be limited. For the scope of this paper, I keep an open mind to intuitions arriving in the mind in metaphysical ways, therefore, the consciousness is defined to allow this possibility. Wynter claims that the subjective experiences of our consciousness correlate to neural processes – but that it would be a bio-centric bias to assume that these processes give rise to or have a causal relationship with consciousness. In other words, consciousness does not come *from* the physical - it comes *to* the physical. Consciousness causes neural responses, but does not arise from them. It is here that I infer intuition. Jung (2009) also bemoans our modern, materialistic view, claiming it robs us of the quest for meaning.

> The fact that a metaphysics of the mind was supplanted in the nineteenth century by a metaphysics of matter, is a mere trick if we consider it as a question for the intellect; yet regarded from the standpoint of psychology, it is an unexampled revolution in man's outlook upon the world. Other-worldliness is converted into matter-of-factness; empirical boundaries are set to man's discussion of every problem, to his choice of purposes, and even to what he calls "meaning." Intangible, inner happenings seem to have to yield place to things in the external, tangible world, and no value exists if it is not founded on a so-called fact. (Jung et al., 2009, pp. 174-175)

An intuitive idea, for the purposes of this paper, is one that arrives in the consciousness in a whole form, without necessarily revealing its origin or its parts from previous, biological, neural activity. It is the thesis of this whole paper that a new type of education could be built on improving the reception of intuitive ideas. These would be to the benefit of the understanding of many STEM subjects such as quantum physics, epigenetics, evolution, and others - not to mention the benefits the intuit receives by being in touch with one's inner self. This new education would be based on the interaction between the intuitive right brain and the analytical left brain, working in concert. But, because this is contrary to most scientific thought, defending

that intuitions may have a non-physical, non-material basis sometimes makes for a lonely, difficult position.

> The spirit of the age cannot be compassed by the processes of human reason. It is an inclination, an emotional tendency that works upon weaker minds, through the unconscious, with an overwhelming force of suggestion that carries them along with it. To think otherwise than our contemporaries think is somehow illegitimate and disturbing; it is even indecent, morbid or blasphemous, and therefore socially dangerous for the individual. He is stupidly swimming against the social current. Just as formerly the assumption was unquestionable that everything that exists takes its rise from the creative will of a God who is spirit, so the nineteenth century discovered the equally unquestionable truth that everything arises from material causes. (Jung et al., 2009, p. 175)

Piaget (1950), Vygotsky (1966/2011; 1978), and Bandura (1971) show that early childhood cognition includes a stage where the child produces novel responses that are intelligent, yet completely untraceable to prior experiences. At that same stage, it can be shown experimentally that while the child embraces whole ideas, the child cannot break those whole ideas into parts (J. Piaget & B. Inhelder, 1969). Very soon after shifting from this stage, the child can break up whole ideas and therefore can perform abstract, analytical reasoning (Bandura, 1971; Piaget, 1950; J. Piaget & B. Inhelder, 1969; L. Vygotsky, 1966/2011). Wynter speaks of the inability to explain certain ideas to a person of a different “order of consciousness” (Wynter, 2001, p. 32) much in the same way that Piaget describes how one cannot explain certain ideas to a child at an earlier stage of cognitive development (Piaget, 1950; J. Piaget & B. Inhelder, 1969). Vygotsky argues that it "is easy to see that consciousness cannot be regarded as a phenomenon of a second line, neither biologically, physiologically, nor psychologically" (L. Vygotsky, 1979, p. 11). Therefore, consciousness is a primary, human behavior that lies within the non-physical area of thought and is inextricably accompanied by thought. With this in mind, let us now broadly sketch the changes in consciousness that occurred near some origins of civilization.

The Social History of Consciousness: Matriarchy

One current study surveyed approximately two thousand people in Germany and Spain and found that "Females believe more strongly in the intuitive power of women, and males in that of men" (Gigerenzer, Galesic, & Garcia-Retamero, 2013, p. 62). This study was interesting because as it examined such stereotypes more closely in domains such as personal, social, scientific, leadership, danger, and stock investments, it was found that "Stereotypes exist, but are domain-specific rather than domain-general" (Gigerenzer et al., 2013, p. 69). In other words, we have stereotypical views on modern intuitive powers as they relate to gender just as we have stereotypes about our ancient ancestors. Some researchers believe that there existed early matriarchal societies that were quite intuitive, or what we now call right-brain dominant (Diop, 1974; Houston, 2007; Stone, 1976). The evolution of consciousness is a central theme in the mythologies of many early human civilizations (Casas, 1992; Diop, 1974; Graves, 1875; Houston, 2007; Loewen, 1995; Stone, 1976; Teresi, 2003). Some of the earliest evidence of civilization lies in what is now Africa (Diop, 1974; Houston, 2007; Loewen, 1995; Stone, 1976; Teresi, 2003). A large body of early historical research was lost in the destruction of the library at Alexandria (Diop, 1974), but some early human records reveal Ethiopian civilizations in what is now the north eastern part of the African continent (Diop, 1974; Houston, 2007; Stone, 1976). Houston (2007) argues that the oldest records she has found, report that the Cushite colonies were in the valley of the Nile, Barabra, and Chaldea no later than 7,000 or 8,000 B. C. Stone (1976) asserts that these early societies were matriarchal. Women were revered, according to Stone, and ran the society. A Goddess, known in most historical documents as the Queen of Heaven (also known as Earth Mother), was worshipped above a God. “There were records of such Goddesses in Sumer, Babylon, Egypt, Africa, Australia and China” (Stone, 1976, p. 3). Stone explains that “Diodorus wrote of warrior women existing in Libya, reporting that these

women had formed into armies which had invaded other lands. According to him, they revered the Goddess as their major deity and set up sanctuaries for Her worship" (Stone, 1976, p. 35). The man in such societies often had a role that is the reverse of current societies. "Herodotus of Greece, several centuries before Diodorus, wrote that in Egypt, 'Women go in the marketplace, transact affairs and occupy themselves with business, while the husbands stay at home and weave'" (Stone, 1976, p. 36). Diop corroborates these findings, asserting that in the ancient society, the "matriarchal system is the base of the social organization in Egypt and throughout Black Africa" (Diop, 1974, p. 142).

Stone reports bias in the historical treatment of such societies. She claims that males from our current, patriarchal society project modern values onto the past and disrespect the values of the peoples that they research and simultaneously devalue the intuitive powers of such societies.

> Priestesses of the Goddess, who provided the counsel and advice at Her shrines of prophetic wisdom, were described as being fit for this position since as women they were more "intuitive" or "emotional," thus mediums for divine revelation. These same writers generally disregarded the political importance of the advice given or the possibility that these women might in fact have been respected as wise and knowledgeable, capable of holding vital, advisory positions. Strangely enough, emotional qualities or intuitive powers were never mentioned in connection with the male prophets of Yahweh. (Stone, 1976, p. xxi)

Stone's work reveals that modern researchers demonstrate a bias that has two distinct aspects. On the one hand, she shows that researchers today live in a patriarchal culture and often picture historical scenes as through a male dominated lens. A second aspect of this bias, according to Stone, is that current researchers live in a consciousness that does not respect the earlier, intuitive consciousness of the matriarchal societies. This echoes the work of Wynter (2001) and Lee (2005) as they describe the inability of so many writers today to appreciate that consciousness has changed throughout history – and that the change has landed us in a position from which we cannot always understand the way previous thought paradigms were constructed. While Kuhn's

(2004) work on human paradigm shifts in thinking is a landmark in this arena, it is the goal of this paper to shine a spotlight on the aspect of consciousness shifts as primal and causal of STEM advances and even STEM regressions. The male dominated lens has been a consciousness shift away from intuition of whole ideas toward analytical thinking in parts. This is similar to the way that early childhood cognition shifts from embracing whole ideas to taking ideas apart, analytically. The matriarchal society could still nurture ideas and see them as whole, relational, intuitive paradigms. The patriarchal shift was accompanied by more analytical thinking; but it also seemed to signal the decline of an intuitive phase. So, when Stone tries to present a second paradigm – that of matriarchy - to coexist with equal importance to patriarchy, the modern lens has trouble seeing those two ideas at one time (Stone, 1976, p. 29).

Consider as an example, the specific shift in consciousness that occurred to the region from Africa to Greece around 2,000 BCE to 1,000 BCE. This was the time that immediately preceded Homer, Pythagoras, Socrates, Plato, and Aristotle. This shift occurred around the same time as the change from matriarchy to patriarchy. It paralleled the cognitive shift later in this paper that occurs in most children around the age of three or four. It is characterized by the human consciousness losing the ability to embrace whole ideas easily – and gaining the ability to analyze ideas, dividing them into parts. The nurturing Africans of 2,000 BCE gave way to a patriarchal group that could divide and conquer, looking out more for the individual, than the group.

The Social History of Consciousness: Patriarchy

Recent studies show that that there is a cultural dimension to students leaving STEM programs (White, Altschuld, & Lee, 2006) as well as gender differences (McCullough, 2011; Weber, 2012). Certain educators advocate teaching explicit social justice and racial issues within

the curriculum (K. D. Brown & Brown, 2011). Others argue that "the low proportion of genetic variance across racial groupings strongly suggests a re-examination of the race concept" (R. A. Brown & Armelagos, 2001, p. 34), and thus imply that such broad generalizations about racial categories "leads to faulty and misleading conclusions about the nature and origin of human differences" (R. A. Brown & Armelagos, 2001, p. 38). This paper seeks to generalize to some extent however, painting a broad brushstroke about gender and racial injustice as they relate to STEM teaching in schools. It welcomes the right-brain tendency to integrate the whole picture of social issues with STEM. It seeks to stand in the shoes of the boy who simply said, "but the emperor has no clothes", rather than shirk responsibility for perpetuating a bias against women, certain races, and the intuitive, right-brained individual.

It is known that the Cushites of ancient Ethiopia had developed astronomy among many other sciences, technologies, engineering techniques, and mathematical advances (Diop, 1974; Houston, 2007). In fact, early civilizations in Africa, India, and Asia - well before the Golden Age of Greece - pioneered alphabetic writings, astronomy, history, chronology, architecture, plastic art, sculpture, navigation, agriculture, and textile industries (Diop, 1974; Houston, 2007; Stone, 1976; Teresi, 2003). It is also known that much of this was done in matriarchal societies that prospered with successful governing bodies, peaceful commerce, and well-run cities that balanced urban technology with their rural agriculture (Diop, 1974; Houston, 2007; Stone, 1976). But patriarchal societies became dominant over time. Today, the sociology of a great majority of the world is patriarchal (Asante, 1991). What happened to our historical knowledge and appreciation of the matriarchal societies?

Historical records that support conjectures of the origins of the northern tribes that invaded the Near Middle East are scarce. Reliable research that both sociologists and historians

can agree on generally begins after the "invasions of the historical period, which began at about 2400 BC, are attested by literature and surviving artifacts and are agreed upon by most historians and archaeologists" (Stone, 1976, p. 63). Another point that is in agreement is that these northern tribes were patriarchal (Diop, 1974; Stone, 1976). But a light can be shown on the social history of the consciousness of the peoples of this region as to the general behavior shifts they exhibited as they changed from a matriarchy to a patriarchy. Female influences and tendencies to nurture, to be intuitive, to approach decision making by more collaborative means, to be more inclusive of members of society, diminished; and male tendencies of making decisions alone, individuality, aggression, exclusivity, and assertiveness, emerged (Diop, 1974; Houston, 2007; Loewen, 1995; Stone, 1976). Transformations of this magnitude impact one's entire world view. This is a consciousness shift. And the implications to such things as the STEM theories entertained, the technology that is invented, and the engineering processes that are implemented are directly affected. It was around this time that bronze metalwork started to give way to iron, that pottery became glass, and that simple wheels were transforming into gears. This was the time of indoor plumbing and the Roman arch. Kuhn describes world view shifts "as elementary prototypes for these transformations of the scientist's world that the familiar demonstrations of a switch in visual gestalt prove so suggestive. What were ducks in the scientist's world before the revolution are rabbits afterwards. The man who first saw the exterior of the box from above later sees its interior from below. Transformations like these, though usually more gradual and almost always irreversible, are common concomitants of scientific training" (Kuhn, 2004, p. 111). It is the conjecture of this paper that this elusive thing called the *consciousness* has everything to do with human shifts in paradigm and world view. Specifically, I believe that this prototypical shift around 2,000 BCE in the north of what is now the African continent, is from right-brain

dominance to left-brain dominance. I believe that is one example that represents one of the most significant global transformations in recorded history, namely, the shift in human consciousness from version 1 (intuitive, right-brain) to version 2 (analytical, left-brain). Furthermore, all of the STEM activities that followed reflected this. Our science, technology, engineering, and mathematics were viewed through an increasingly analytic, logical, left-brain lens after this consciousness shift. If one steps back to see patterns in the engineering that mirrors consciousness, one sees increased movement from whole to parts. Like a child pulling away from the mother, humankind separated from natural materials and processes and began to refine materials and break down and imitate natural processes by making mechanically conceived, human-made ones. Stone tools became bronze, then iron. Unworked clay became refined glass. Wheels became individuated into myriad parts of wheels that became gears. Living near streams transformed to re-routing streams into irrigation and plumbing systems. Log bridges and waterways became hand made arched roads and aqueducts.

Further, it is important to note that many of these transformations of humankind's technological processes toward mechanization and separated parts took place at *roughly the same time*. The two millennia surrounding this shift saw the birth of engineering and new technology in several parts of the world. The ancients that occupied what is now China perfected gunpowder, paper, and the compass. The Olmecs of modern day Mexico ignited an agricultural revolution for much of the Old World that became approximately 60% of our current cultivation (primarily corn and potatoes). As hydrology advanced in Egypt, the Hitites invaded Babylonia matching military machines against water powered corn mills that used wheels, and Cushites in what is now Africa built a 100 mile wall that if stretched end to end with its 500 communal

enclosures, would be 10,000 miles long. The Cushite builders of this wall moved more stone than the largest Egytian pyramid (Teresi, 2003).

So, to recap, the basic premise being asserted in this paper: that consciousness changes, led to a sub-premise: that the *way* human consciousness changes follows three main swings from: 1) intuitive to 2) analytic, to 3) both in balance. But, now I have added that STEM progressed with different peoples, in different parts of the ancient world (who were not in direct communication with each other), in roughly similar time periods. I therefore assert another sub-premise: that many human consciousness shifts were globally synchronous. Much the same as children all over the world seem to change from intuitive to analytical, even though they are seemingly separated from each other and experiencing very different environments; humankind seems to have grown up from childhood to adolescence as if it were one, global child. This seems to be evidence of Jung's (2009) collective unconscious at work, because the synchronicity of physically separated groups all shifting to analytical-mechanical technologies during the same time period is more than a mere suggestion that their minds were perhaps unknowingly in communication on an unconsciousness level.

Trends toward increased left-brain dominance continued until quite recently in the 1800s (Jung et al., 2009), at which time right-brain dominance began to come back. A detailed examination of evidence that supports this next turning point, namely, from version 2 to version 3 (balance) would require another paper. My purpose here is to assert that consciousness has been shifting and is continuing to shift. And more importantly, it has shifted like two broad swings of a pendulum from right to left and may now be turning back. Getting back to the turning point from matriarchy to patriarchy around 2,000 BCE, it was of course not just views of

what we now call STEM that changed, there were also significant historical and sociological transformations.

Historical / Sociological / STEM Overlaps

The clash that occurred when the whites from the north met the blacks from the south seems to be a prototype of polar opposites harboring biases. It represents trends that have endured to form the present threads of our modern sociological fabric where many of these biases still exist. Instead of the right-brain inclusion of diversity in groups, left-brain judgments of differences entered whereas "evidence suggests that it was these northern people who brought with them the concepts of light as good and dark as evil (very possibly the symbolism of their racial attitudes toward the darker people of the southern areas) and of a supreme male deity" (Stone, 1976, p. 66). Differences in races were problematic as they were paired with a consciousness that was moving away from the matriarchal worship of mother earth to a more patriarchal, individualistic basis for decision-making and religious practice. "Thus it may have been that the patriarchal invaders, who saw women as inferior, are responsible for the origins of racist attitudes as well" (Stone, 1976, pp. 71-72).

This is why we must study history in order to understand STEM. As Aristotle (1984) articulated the differences between quantitatively and qualitatively handling phenomena, science increased in the study of particulates. Slowly a movement from studying qualities to quantifiable measurables became synonymous with good scientific method. But the problem with this shift is that we educate young scientists to miss valuable qualitative information. By shifting consciousness from the right to the left brain, we increase some abilities and lose others. "Everything we've noted about qualities points to the fact that they are expressions of consciousness" (Holdrege & Talbott, 2008, Locations 2137-2138); but it is precisely issues of

qualities that have avoided measurement, because, as Galileo said, they "reside only in the consciousness" (Galilei, 1957, p. 274). One must ask, how much better could science advance if we could capture both left and right-brain information? Sociologically, the shift in consciousness from a matriarchal to a patriarchal society, saw inclusive ways of thinking give way to exclusive ways of thinking that separated and stratified members of society (Diop, 1974; Houston, 2007; Stone, 1976). Analytical, abstract reasoning gave birth to division of labor, a new and pervasive form of slavery, and capitalist forms of the economic structure that favored certain individuals over others (Diop, 1974). In many cases, division, whether sociological or scientific, may have created seeds of aggression where workers were to be exploited by the more powerful capital owners. This could only have exacerbated slavery practices. To be sure, certain disputes had previously existed between societies in the earlier matriarchal era (Houston, 2007; Stone, 1976); and the practice of a certain form of slavery also subsisted (Diop, 1974; Stone, 1976). But the consciousness shift in humanity that could abide by this era of patriarchy saw a new form of self serving aggression of one group against another; and it saw that "man has invented nothing worse than slavery to degrade and exploit his fellow man. Hence, the truly revolutionary regimes are the slave regimes, whether the brutal slavery of ancient Greece or the barely disguised but not less virulent slavery of the Western Middle Ages. That is why, with the development of ancient or modern capitalist production, both those societies led to revolution" (Diop, 1974, p. 223). It should be noted that Diop falls into a group of researchers that have definite detractors who would complain of historical bias and over-generalized racial categorization (R. A. Brown & Armelagos, 2001; Keita, 1981). But, he is honored here for questioning why schools do not discuss matriarchal, African, and intuitive historical influences enough.

Patriarchy as Related to STEM Practices

The definition of the word analysis involves the concept of separation – to analyze is to separate. This was an essential element in the consciousness of the patriarchal society. They were analytical in thought and separatist in nature. The patriarchal society and the patriarchal individual in such a society was analytical in a way that caused both scientific and social separation, and with this came oppression(Diop, 1974). This is not meant to denigrate the strides in STEM advancements that this leap in left-brain thinking afforded. Great strides took place across India, Egypt, Islam, and China in mathematics, astronomy, technology, Greco-Roman culture, medicine, engineering, and pre-cursors to modern physics during this millenium. This was the flourishing of forms of the: magnet, compass, abacus, odometer, astrolabe, sun dial, lever, wheel, inclined plane, use of acids and bases and salts, trebuchet, and studies of parabolic motion. Socially, individualization brought possibilities of human freedom and the beginnings, in Greece, of what would become democracy. But we can no longer study history as a one-way story of upward progress. There were losses, also. A price humankind paid for a focus on left-brain analytical thinking was the loss of right-brain connection to nature and each other.

It would be reasonable at this point to ask for an example of what a balanced-brain scientist might be able to do that is better than a left-brain dominant scientist. This author suggests that we have an opportunity to do this in genetics right now. If one considers that human health and human behavior is limited to what the gene map instructs, then we may remain bound by a physical, mechanistic, left-brain view of any data that is collected. But if one looks outside the gene as well as at the physical material, one sees epigenetic influences from electromagnetic fields, which are produced in response to *intention* in our consciousness. There may be a question here of influencing the RNA to DNA reproduction process to go against the instructions of the gene map. Perhaps this would suggest research into the possibility of human

intention affecting cellular replication. In other words, using holistic genetic relationships in addition to mechanical ones, we may find that humans are not the victims of genetic dispositions as we once believed.

> What stands on the biochemical and supposedly causal side of the relation never clearly relates to the trait, and certainly fails to explain it in any adequate sense. This is because the trait-whether it is dark skin, green eyes, cancer, or an aggressive tendency-is quite properly understood in qualitative and meaningful (word-like) terms, whereas the 'causal' gene remains at the level of mechanism, not language. The reason for this is that causes and mechanisms are no more able to originate meanings than grammatical rules are able to originate or explain the things we say (Talbott, 1995). (Holdrege & Talbott, 2008, Locations 1345-1348)

Forgotten History - a Product of Modern Projection onto the Past

In a STEM context, psychological projection - the act of assuming that another's thought patterns are like your own - is a double-edged sword. On the one hand, projection allows a freedom from earlier scientific limitation and habit. "Science represents the office of intelligence, in projection and control of new experiences, pursued systematically, intentionally, and on a scale due to freedom from limitations of habit. It is the sole instrumentality of conscious, as distinct from accidental, progress" (Dewey, 1916/2005, pp. 181-182).. But, on the other hand, projection of current attitudes can cause humankind to bury past wisdom because we may have lost the ability to see what we formerly knew. Projecting modern modes of consciousness on the past can be a self-perpetuating and self-reinforcing effect of over-emphasis of intellectual left-brain over intuitional right-brain. We may have forgotten ways of understanding nature that could bring our current technology and engineering forward. If we are to continue learning from nature's subtle interconnections that we have lost the ability to perceive, then STEM advances are being held back by our lost wisdom and by the unbalanced thinking that makes possible the projection of our current paradigms onto the past. For example, mechanical and mathematical

models of Galilean and Newtonian physics made advances with the: pendulum, clock, telescope, and vacuum tube possible. But the ideas of the separateness of material objects that conceived of these advances and such notions as action-at-a-distance, proved to be a detriment in conceiving of relativistic and quantum notions. Again, something was gained and something was lost.

Evidence of humankind emerges from pre-recorded history to recorded history revealing that at least in part, our species began in a more intuitive state, then progressed to a logical, analytical state (DeBoer, 1991; Kuhn, 2004; Nisbett, 2003; Teresi, 2003; Wynter, 2001). So it is with the life of one single human being. Cognitive experts have long established that the child begins more in a right-brain intuitive state and progresses to a more left-brain analytical state (Bandura, 1971; Piaget, 1929/2007; L. Vygotsky, 1962, 1966/2011, 1979; L. Vygotsky & Cole, 1978). Further, it seems to be in like manner as one drills in to more specific detail to examine the way a single person begins a day. We know from personal observation that the act of waking from a dream state is more intuitive and the reasoning left brain engages as the day progresses. Drilling even further we can examine the anatomy of a single act of experiencing something new. McGilchrist (2009) has done extensive research in the area of brain research with careful respect for the many forms of collaboration between the left and right lobes that is emerging in recent studies. He is cautious in generalizing about the five types of attention: vigilance, sustained attention, alertness, focused attention and divided attention found in conventional neuropsychological literature. He does conclude, however, that there is a difference in the right and left brain in handling each new experience. "If it is the right hemisphere that is vigilant for whatever it is that exists ‘out there’, it alone can bring us something other than what we already know. The left hemisphere deals with what it knows, and therefore prioritises the expected – its process is predictive. It positively prefers what it knows" (McGilchrist, 2009, Locations 1102-

1104). Arnheim argues that each thought is received as a whole idea in an intuitive state and then becomes analyzed as we consciously look at it (Arnheim, 1986a, 1986b; Eisner & Education, 1985). Therefore a pattern emerges that suggests that there is an evolutionary set of stages from intuitive to analytic in the act of thinking. Perhaps it was the evolution of the human consciousness that was bound to move in this same way. Either way, the child's stages can be mapped in order and kind onto the history of humankind and vice versa.

By the mapping above, it must be noted that just as a child forgets early intuitive notions and, in fact, the ability to be intuitive, so does humankind. History has been forgetting earlier forms of wisdom and knowing. And with this forgetting came the lack of intellectual discussion of a direct, intuitive way of acquiring knowledge. This loss of intuitive wisdom has had a materializing effect on humanity. It has pervaded the literature, where knowledge is portrayed as a product of material, physically-bound communication and experience and qualitative realities are ignored. In other words, whereas moderns assume that the spread of STEM ideas and techniques must have taken place by direct, physical contact between groups of people, ancients assumed that a group mind not unlike the hive mind of bees (Thomas, 1974) could spread knowledge and abilities from one part of humanity to another. As humankind grew up, analytical thinking increasingly caused separateness and races became painfully aware of stark contrasts to each other and the issues of superiority and inferiority came into sharp focus. ‘Otherness’ was noticed to a greater degree as humans became against other humans with increased racism. Humans changed from feeling one with nature to a desire to conquer nature and exploit the other animal and plant species. Wholeness, relationship, and community lessened as individuality, power, and slavery increased. While this opened the door to the industrial, scientific, technological, and information revolutions, it closed the door to intuitive investigation. Through

projection of the current human condition onto our own past, we have buried the fact that we once had *and used* this intuitive ability. And along with this forgetting comes a distinct lack of intellectual interest in the period before recorded history. It is almost as if human wisdom and knowledge are assumed to begin with our written records. Perhaps this paper is also a call for research studies of pre-recorded history, if only we could creatively imagine how this could be done. Since I have alluded to early childhood as a parallel phenomenon to early stages of humankind, perhaps one form of research into human history could be through the cognitive development of the child. A pertinent question that therefore arises is, "Can comparisons be drawn between the development of stages of the consciousness of humankind and cognitive stages of the child"?

The Cognitive Development of Early Childhood as a Parallel to the Development of Early Human Consciousness

The early cognitive development of the human child parallels the early development of the consciousness of the human race as it moved from the matriarchal, intuitive consciousness to the patriarchal, analytical way of thinking and behaving. It will be helpful at this point to compare writings on cognition of Albert Bandura (1971) Jean Piaget (1929/2007, 1950, 1959, 1965, 1973, 1976; 1927/2001), and Lev Vygotsky (1962, 1966/2011, 1979; 1978). Both the child and the early human receive perceptions without a perceptible outer stimulus (Bandura, 1971; Piaget, 1950; J. Piaget & B. r. Inhelder, 1969; L. Vygotsky, 1979; Lev Vygotsky, 2002; L. Vygotsky & Cole, 1978; Warford, 2011; Wertsch, 1985). This act of behavior is considered, in some cases, to have arisen within the human as an intuitive perception; but more often it is experimentally recorded as a shift in behavior with an unknown origin (Bandura, 1971; Piaget, 1950; J. Piaget & B. r. Inhelder, 1969; L. Vygotsky, 1979; Lev Vygotsky, 2002; L. Vygotsky &

Cole, 1978; Wertsch, 1985). Vygotsky offers an explanation for this by describing a zone of proximal development (ZPD), defined as the distance between a child's "actual developmental level as determined by independent problem solving" and the higher level of "potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (1978, p. 86). Whenever one comes to know something, the question of intuition arises. The question of whether the seemingly new knowledge came from an assemblage of prior elements or somehow arrived as a completely fresh insight is extremely important here – and is quite controversial (Bandura, 1971; J. Piaget & B. r. Inhelder, 1969). Another question arises as to the nature of the influence of the people who accompany the child who arrives at the new insight. Did an adult facilitate this insight? Was it passed from adult to child or inspired by social contact with peers? These are excellent questions for another investigation of the factors by which new insights can be stimulated – in fact it is the hope of this paper to motivate the need for more research into this area. My intention is only to establish that there exists a point where the human arrives at insights where there are no perceptible a priori stimuli – and that this is recorded in modern experiments in early childhood cognition, as well as in early records of the history of the human race. Vygotsky describes how children, generally before the age of three or four, do not analyze, abstract, or break up whole, tangible concepts:

> Experiments and day-to-day observation clearly show that it is impossible for very young children to separate the field of meaning from the visible field. This is a very important fact. Even a child of two, when asked to repeat the sentence “Tanya is standing up” when Tanya is actually sitting in front of him, will change it to “Tanya is sitting down.” (L. Vygotsky, 1966/2011, Locations 168-170)

One could compare this early stage of childhood to the stage of humankind just prior to recorded history in order to see if there are key similarities. In both cases, there is a tendency to live in the moment, experiencing what is directly in front of the individual as an indivisibly whole event

without writing about it, analyzing it, or reflecting on it. In both cases, the use of the abstraction of words to signify a portion of the meaning of the whole experience is antithetical, perhaps impossible. According to Piaget, pictures or symbols seem to be imagined for a child in these early stages. The adult observer of the child may call these imagined because both their origins and their stimuli are imperceptible to the observer as "preconceptual reasoning" (Piaget, 1950, p. 140). It is presumptuous to assume that one can discuss human cognition from the period of time before recorded history, except to say that the very next period, in all likelihood, was some sort of continuation of it and therefore exhibits vestiges of similar behaviors, perhaps in diminishing amounts. The consciousness of the people of the early, matriarchal period are reported to have dealt in whole concepts, at times perceiving intuitive knowledge without necessarily having used the processes of analytic deduction or induction (Diop, 1974; Stone, 1976). In other words, they sometimes saw ideas without building them up from parts. Extrapolating backwards, then, it is conceivable that the people just prior to this group saw ideas in inextricable wholes. If so, they would share this trait with the child of about two years old.

> In a very young child there is such an intimate fusion between word and object, and between meaning and what is seen, that a divergence between the meaning field and the visible field is impossible. This can be seen in the process of children's speech development. You say to the child, "clock." He starts looking and finds the clock, i.e., the first function of the word is to orient spatially, to isolate particular areas in space; the word originally signifies a particular location in a situation, so-called reality perception. This is something for which there is no analogy in animal perception. Essentially it lies in the fact that I do not see the world simply in color and shape, but also as a world with sense and meaning. I do not see merely something round and black with two hands, I see a clock; and I can distinguish one thing from another. (Lev Vygotsky, 2002, Locations 175-192)

Bandura also speaks of the fact that early developments of cognition are not simply motivated by association through repeated imitation. The child responds to certain social stimuli with more frequency than others. And novel responses, those defined as not having perceptible origins, appear without observable stimuli where, according to Bandura, "the principle of association

does not adequately account for the fact that behavior is controlled by some social stimuli, but not by others that have been associated with equal frequency. A more serious limitation is the failure of these formulations to explain how novel responses are learned to begin with" (Bandura, 1971, pp. xvi-xvii). Bandura is careful not to assume that novel responses arise within an individual from random causes. He considers the use of novel responses to be a way of learning. He notes that some theorists do not call this new behavior - formed from novel, unique combinations – learning. But he does, and he cites the great innovator, Beethoven as exemplifying a form of learning from the combining of associative parts that have been previously observed – but placing them together in new, novel responses. I therefore pose the question, "Could Beethoven be an example of the action of a fully developed, logical adult accessing the intuitive capabilities of a child to perceive the wholeness of parts of an ensemble?"

STEM History from Pre-recorded to 2,000 BCE / The Child After Three or Four Years Old

A child begins a form of abstract reasoning that will mature approximately from the age of three or four to the age of seven. An important point should be noted, here. Many studies are investigating the permanence of stages in human cognition. It is not the intent of this paper to advance stage theory; and it is not needed to develop the arguments contained herein. The point here is that a type of abstract thinking does develop in almost every child. This thinking allows for the separation of meaning from experience in both analytical deduction and induction (Piaget, 1950). This is the time where a child can play in such a way that a form of pretending can separate meaning from a real object and assign it to an intermediary object (such as pretending a stick is a horse) (Lev Vygotsky, 2002). From the age of roughly three or four to seven years old, childhood cognition may be likened to the period of human history up to approximately 2,000

BCE. STEM inventions became mechanical. Natural processes became replaced increasingly by machines. Cushites in the Sudan made a hydraulic system for irrigation of agriculture. They also developed iron metallurgy that still exists today. The Aztecs delineated the human anatomy, naming all of the organs and the circulatory system. The Toltec Mayans created sophisticated acoustic structures, while the Mayans of Yucatan developed concrete causeways to connect cities with observatories, temple pyramids, and palaces. The Chinese made rudders for ships, canal lock gates, stirrups & harnesses for horses, fishing reels, hot air balloons, the seismograph, gimbals, the umbrella, crank handles, kites, mechanical clocks, paper money, convertible bank notes, agricultural row cultivations, and an iron plough (Teresi, 2003).

Children at this age pull away from the mother, become more individualistic, egoistic direction enters the behavior, and the analytical level of abstract thought allows for the development of reading, writing, and arithmetic. World civilization changed at this period from matriarchal to patriarchal. Civilizations that were much closer to mother figures and intensely interested in the relationships within the community, became dominated by war-like groups that sought individual power through egotistical leadership, increased abstract, intellectual writing and mathematics (Diop, 1974; Houston, 2007; Stone, 1976). But this period between three or four years of age and about seven years of age appears to be a sort of gestation period for the early child becoming an adult in thinking and consciousness. Vestiges of intuition definitely remained, but slowly diminished as logical thinking became dominant. Previously “unanalysable relations" (Piaget, 1950, p. 146) begin to separate in the child’s consciousness. But, especially at the beginning of this phase, the child still relies heavily on whole pictures and intuitive reasoning.

INTUITIVE THOUGHT

> The forms of thought we have been describing can be analysed only through observation, since young children's intelligence is still far too unstable for them to be interrogated profitably. After about 4 years, on the other hand, short experiments with the subject, in which he has to manipulate experimental objects, enable us to obtain regular answers and to converse with him. This fact alone indicates a new structuring. In fact, from 4 to 7 years we see a gradual co-ordination of representative relations and thus a growing conceptualization, which leads the child from the symbolic or preconceptual phase to the beginnings of the operation. But the remarkable thing is that this intelligence, whose progress may be observed and is often rapid, still remains pre-logical even when it attains its maximum degree of adaptation;1 up to the time when this series of successive equilibrations culminates in the "grouping", it continues to supplement incomplete operations with a semi-symbolic form of thought, i.e. intuitive reasoning; and it controls judgments solely by means of intuitive "regulations", which are analogous on a representative level to perceptual adjustments on the sensori-motor plane. (Piaget, 1950, pp. 142-143)

There is a loss of fluidity that a person experiences in adult life as compared with childhood, that forms such an informative parallel if we consider humankind as nearing its adulthood. But there are adults who retain or regain child-like enthusiasm and agility of assimilating new ideas. What would be the implications of a method whereby we could help children to temporarily lose intuition, then regain it as they become adults? What if education nurtured, strengthened, and developed intuitive powers, even as analytic-intellectual ones presently are tended in developmentally appropriate stages?

Educational Implications

The purpose of this paper is to show that human consciousness is changing. This has lead to the point that the intuitive thought of early human stages of consciousness may be attainable and useful, today. I have attempted to show that an early version of humankind used intuition to receive ideas in large, whole pictures. Then, in a second stage or version of humankind, this intuitive ability slowly diminished and analytical thought began to dominate our consciousness. I then drew parallels of these stages to early childhood.

The suggestion has also been advanced that the adult may have the ability to re-integrate intuitive faculties, and therefore perhaps humankind may now be entering a similar stage or

version where a balance of intuition and analysis may be possible. As Mezirow advocates transformative learning in adult education and putting theory to practice, he underscores the importance of "consciousness raising" (1997, p. 10). There is a cognitive stage from about three to seven years of age where both intuitive and operational methods of thought coexist (Piaget, 1950). Some controversial theories of learning believe that novel responses of both the child and the adult can combine previously known entities into entirely new creations such as the great masterpieces of innovation of the likes of Beethoven (Bandura, 1971) and great STEM individuals (Kuhn, 2004). Therefore, the suggestion of this paper is this: perhaps an adult today could use both intuition and analysis to become, as Vygotsky (1962) puts it, what he not yet is.

According to Bandura, "A much-needed 'new look' in studies of child language learning, stimulated by transformational grammar and characterized by the work of such psychologists as Roger Brown, Susan Ervin-Tripp, and Martin Braine, has emphasized the creative and original aspects of the child's learning, and has minimized the role of imitation, the traditionally overburdened explanatory device in this realm (Braine, 1963; Brown & Bellugi, 1964; Brown and Fraser, 1963; Chomsky, 1965; Ervin, 1964; Fraser, Bellugi, & Brown, 1963; Miller and Ervin, 1964)" (1962). This new entrance of sentences that a child has never heard, which is not just a logical remixed set of known words, may be to a child, what the electromagnetic field was to Faraday, relativity was to Einstein, or quantum probability was to Schrodinger. If learning employs both operational methods and intuitive perceptions of whole, new ideas, think of what this may mean to the way we educate children.

Both elementary and high school children need at least one thing that was necessary when they were in kindergarten; something they will also need when they grow old. They need

to keep transforming, to keep growing in character. An education that teaches you how to get in touch with your character will leave you in good stead for life.

> For Froebel [the creator of kindergarten] the purpose of the kindergarten is not to give the child a head start in information acquisition, although it has sometimes been co-opted to serve just this end. Instead, experimentation and play is an opportunity to bring out the inner nature, helping the student find and define himself or herself accordingly. Without sufficient free space, especially psychological space, it becomes difficult to play out our inner natures. Without such experimentation, the self tends to be overly shaped from the outside, rather than drawn forth from within. Play and experimentation may reveal a sense of one's character and calling. (Hart, 2001, p. 14)

The form of experimentation and play referred to by Hart is precisely what an intuitive education would provide. Scientists of the distant past studied nature without constant chatter in their minds. They let nature do the talking. Modern scientists of the last few thousand years increasingly used the left brain to move from one Kuhnian paradigm to the next without realizing that they were narrowing what nature could tell them because they were so embedded in their current paradigm. Students of intuition must learn to suspend analysis and the act of jumping to conclusions. For example, in an actual engineering class where students experiment with filtering water, an intuitive approach might recommend that students try several ways to make muddy water clear. Or maybe math students would be given plenty of time to find more than a few ways to estimate the number of molecules in a quantity of some chemical. Or perhaps a science class would suspend all goals and conclusions completely and simply watch the beauty of a plant pigment creeping into filter paper, just to see how it separates into colored patterns like a watercolor painting. To find and develop your character and get to know your inner self, there must be experiences that do not simply get answers, but instead reveal to yourself how you operate, by allowing the student the latitude to play. STEM classes are not separate from poetry and art classes where a student can get in touch with inner feelings and subjective experiences. The STEM/artist can and should constantly cause the student to see herself or himself by

revealing how one relates to play and experimentation. Innovations can occur when we are watching and listening to nature with quiet minds - without our need to ask questions first, then limit what we investigate. Both in learning who we are in the deeper sense and in learning who nature is in the largest sense, we must do more reading and listening and less questioning and talking.

Modern science has outgrown and continues to outgrow its own left-brain, materialistic assumptions; its own future depends on a new, balanced cognitive approach. When a STEM student today is taught the Theory of Complementarity, it is often explained that light is both a particle and a wave. The student learns that two concepts that cannot be understood by the analytical mind to be true at the same time seem, under experimentation, to be so. The only way for a student to integrate this idea – and truly learn it – is to use the intuitive right-brain faculty of learning. With pure logical, analytical thought one can only say that experiments show this contradiction – but it is just that – a contradiction. Complementarity makes no sense to reason; it violates the law of non-contradiction. Similar problems arise with many historical STEM experiments. To take a few examples from physics, right-brain thinking is helpful and sometimes necessary to understand: electromagnetic induction (Faraday, 1839/1965; Maxwell, 1856/2010, 1873/2010; Maxwell & Torrance, 1864/1982), light theory (Bohr, 1949), entanglement (Young, 1804), relativistic phenomena (Einstein, 1920/2010, 1950/2011), wave probabilities (Schrodinger, 1944/1992), observer effects (Heisenberg, 1950), or even the conspiracy theory from the early Munich quantum experiments (Greenstein & Zajonc, 1997). The concept of quantum co-location states that more than one object can occupy the same location. This does not fit in the historical world of Newtonian Physics because Newton represents the height of left-brain thinking. To the left brain, co-location cannot make sense. If a STEM student uses only

analytical thinking, there is an inability to associate to such an idea. But using both analytical and intuitive thinking, where wholes exist, and both ideas and physical objects can be conceived of as whole and inextricable, the student can begin to see how complementarity, co-location, and entanglement can be understood. If the student's intuitive mind can conceive of the whole tree in each seed, or the whole hive-mind of the bee colony in each bee, then co-location can start to come into view. In an intuitive education, STEM concepts can be paired in the right brain with social theories of coexistence, schema for globalization, countless poems, and musical renditions.

To teach future STEM students in a balanced way, we need to apply the same rigor to scientifically go about the development of the intuitive capabilities that have accompanied so many historical discoveries. These must rival the way Newton (1730/1974) relates his own description of his mathematical work with gravity and color, or Foucault outlines in *The Order of Things: An Archaeology of the Human Sciences* (1971), or Kuhn (2004) explains so carefully in asserting the anatomy of paradigm shifts, or Burke (1980) repeatedly asserts in his life work of studying the connections between technological and engineering advances. But the creative right brain also wants to roam a bit and ask the question, "What are some possible innovations in STEM that might be imagined by students who can balance intuition with analysis?"

We say that art imitates nature. Perhaps STEM does also, but it has increasingly conceived of nature as a machine for some time. What if STEM students could see beyond natural mechanics to look both larger at whole processes and more subtly, also. Would we see how to imitate nature better? Consider some examples balanced STEM students might research. Imagine inventing support structures that can operate with the efficiency of how heavy, white oak tree branches are supported. Imagine a flying apparatus that can approach the weight to

energy ratios of bumble bees or the dexterity of navigating wind the as well as a viceroy butterfly. Imagine airports communicating not from central control towers, but from distributed hive mind technology, like the bees may be doing. Or, what if the healing processes continue to be less and less invasive to the human body, so that we learn the next level of mind over matter from a blend of brain research and the quantum observer effect? When humankind wished to swim like fish, we made boats - but only a crude imitation thereof. We made airplanes to fly like birds - but not nearly as well as butterflies, or even most birds for that matter. What if we wished not for domination, power, and happiness-from-without; then turned our gaze back upon nature and asked, "If we don't form the questions, what answers do you have in storage, waiting for us to hear?"

It is well known that experimentally asking questions of nature axiomatically limits the answers and leads to reductionism. Did you ever look at these optical illusions called 'magic eye' images. At first glance they might appear as random patterns. But if one learns to see past the surface, an image emerges within or perhaps beyond the original pattern. It was there all the time, waiting for the initiate to see it. STEM students might find that there is a wealth of information waiting for the future humans (perhaps humankind, version 3) who can read nature at the next level, perhaps using intuitive capabilities in concert with analytical ones. Obviously, the formation of a new kind of education that includes the training of the faculty of intuition could easily be its own, lengthy treatise. I hope that I have, in some small part, opened the possibility.

REFERENCES

Aristotle, B. J. (1984). *The complete works of Aristotle: The revised Oxford translation*. Princeton, N.J.: Princeton University Press.

Arnheim, R. (1986a). *New essays on the psychology of art*. Berkeley: University of California Press.

Arnheim, R. (1986b). The two faces of gestalt psychology. *American Psychologist, 41*(7), 820-424.

Asante, M. K. (1991). The afrocentric idea in education. *Journal of Negro Education, 60*(2), 170-180.

Bandura, A. (1971). *Psychological modeling conflicting theories*. Chicago: Aldine/Atherton.

Bohr, N. (1949). *Discussion with Einstein on epistemological problems in atomic physics*. Kobenhavn: University of Copenhagen.

Bortoft, H. (1996). *The wholeness of nature: Goethe's way toward a science of conscious participation in nature*. Hudson, N.Y.: Lindisfarne Press.

Brown, K. D., & Brown, A. L. (2011). Teaching K-8 Students about Race: African Americans, Racism, and the Struggle for Social Justice in the U.S. *Multicultural Education, 19*(1), 9-13.

Brown, R. A., & Armelagos, G. J. (2001). Apportionment of racial diversity: a review. *Evolutionary Anthropology, 10*(1), 34-40.

Burke, C. A. (2009). Mindfulness-based approaches with children and adolescents: A preliminary review of current research in an emergent field. *Journal of child and family studies, 19*(2), 12.

Burke, J. (1980). *Connections*. London: Macmillan.

Carroll, L., & Tober, J. (1999). *The indigo children: The new kids have arrived*. Carlsbad, CA: Hay House.

Casas, B. d. l. (1992). *The devastation of the Indies: A brief account*. Baltimore: Johns Hopkins University Press.

Churchland, P. M. (2013). *Matter and consciousness*. Cambridge (Massachusetts); London: MIT Press : Bradford Book.

DeBoer, G. E. (1991). *A history of ideas in science education: Implications for practice*. New York: Teachers College Press.

DeMarrais, K. B., & LeCompte, M. D. (1995). *The way schools work: a sociological analysis of education*. White Plains, N.Y.: Longman.

Dewey, J. (1916/2005). *Democracy and education: An introduction to the philosophy of education*. New York: Cosimo Classics.

Diop, C. A. (1974). *The African origin of civilization: myth or reality* ([1st ed.). New York: L. Hill.

Einstein, A. (1920/2010). *Sidelights on relativity*. LaVergne, TN: Merchant Books.

Einstein, A. (1950/2011). *The theory of relativity and other essays*. New York: Open Road Integrated Media.

Eisner, E. W., & Education, N. S. f. t. S. o. (1985). *Learning and teaching the ways of knowing*. Chicago, Ill.: National Society for the Study of Education: Distributed by University of Chicago Press.

Eisner, E. W., & National Society for the Study of Education. (1985). *Learning and teaching the ways of knowing*. Chicago, Ill.: National Society for the Study of Education: Distributed by University of Chicago Press.

Faraday, M. (1839/1965). *Experimental researches in electricity*. New York: Dover Publications.

Foucault, M. (1971). *The order of things: an archaeology of the human sciences*. New York: Pantheon Books.

Freire, P. (1998). *Teachers as cultural workers: letters to those who dare teach*. Boulder, Colo.: Westview Press.

Freire, P. (2000). *Pedagogy of the oppressed* (30th anniversary ed.). New York: Continuum.

Galilei, G. (1957). *Discoveries and opinions of Galileo*. Garden City, N.Y.: Doubleday.

Gardner, H. (1993). *Frames of mind: the theory of multiple intelligences* (10th anniversary ed.). New York, NY: BasicBooks.

Gardner, H. (2008). *Five minds for the future*. Boston, Mass.: Harvard Business School Press.

Gaskill, T., & Redgrave, L. (2007). *Avicenna and medieval Muslim philosophy*. Boulder, Colo.: Knowledge Products: Blackstone Audiobooks.

Gigerenzer, G., Galesic, M., & Garcia-Retamero, R. (2013). Stereotypes About Men's and Women's Intuitions: A Study of Two Nations. *Journal of Cross-Cultural Psychology Journal of Cross-Cultural Psychology, 45*(1), 62-81.

Glazer, S., Smith, H., & Spirituality in Education, C. (1999, 1999). *The heart of learning: Spirituality in education*, New York.

Goethe, J. W. v. (1840/1970). *Theory of colours*. Cambridge, Mass.: M.I.T. Press.

Goleman, D., & Boutsikaris, D. (2006). *Social intelligence the new science of human relationships*. New York: Audio Renaissance.

Goleman, D., & Senge, P. M. (2007). *Working with presence*. New York: Audio Renaissance.

Goleman, D., & Whitener, B. (2005). Emotional intelligence. Prince Frederick, MD: Landmark Audiobooks.

Graves, K. (1875). *The world's sixteen crucified saviors; or, Christianity before Christ, containing new, startling, and extraordinary revelations in religious history, which disclose the oriental origin of all the doctrines, principles, precepts, and miracles of the Christian New Testament, and furnishing a key for unlocking many of its sacred mysteries, besides comprising the history of 16 heathen crucified gods*. New York: Truth Seeker Co.

Greenstein, G., & Zajonc, A. G. (1997). *The quantum challenge: modern research on the foundations of quantum mechanics*. Sudbury, Mass.: Jones and Bartlett.

Hart, T. (2001). Teaching for Wisdom. *ENCOUNTER: Education for Meaning and Social Justice, 14*(2), 3-16.

Heisenberg, W. (1950). *The physical principles of the quantum theory*. [New York: Dover Publications.

Holdrege, C., & Talbott, S. (2008). *Beyond biotechnology: The barren promise of genetic engineering*. Lexington, KY: University Press of Kentucky.

Houston, D. D. (2007). *Wonderful Ethiopians of the ancient Cushite empire. Book I*. Sioux Falls, SD.: NuVision Publications.

Jung, C. G., Dell, W. S., & Baynes, C. F. (2009). *Modern man in search of a soul*. London; New York: Routledge.

Keita, S. O. (1981). Royal incest and diffusion in Africa. *American Ethnologist, 8*(2), 392-393.

King, J. E., & American Educational Research Association. Commission on Research in Black, E. (2005). *Black education: A transformative research and action agenda for the new century*. Mahwah, N.J.: Published for the American Educational Research Association by Lawrence Erlbaum Associates.

Kuhlewind, G. (2004). *Star children: understanding children who set us special tasks and challenges*. Southport, Merseyside, United Kingdom: Temple Lodge.

Kuhn, T. S. (2004). *The structure of scientific revolutions*. Chicago [u.a.]: Univ. of Chicago Press.

Lemert, C. C. (1999). *Social theory: The multicultural and classic readings*. Boulder, Colo.: Westview Press.

Lemert, C. C. (2004). *Social theory*. Boulder (Co.): Westview.

Loewen, J. W. (1995). *Lies my teacher told me : everything your American history textbook got wrong*. New York: New Press : Distributed by Norton.

Maxwell, J. C. (1856/2010). *Five of maxwell's papers*. [S.l.]: General Books.

Maxwell, J. C. (1873/2010). *A treatise on electricity and magnetism. Vol. 2*. Cambridge: Cambridge University Press.

Maxwell, J. C., & Torrance, T. F. (1864/1982). *A dynamical theory of the electromagnetic field*. Eugene, OR: Wipf and Stock.

McCullough, L. (2011). Women's Leadership in Science, Technology, Engineering & Mathematics:
Barriers to Participation. *Forum on Public Policy Online, 2011*(n2), 11.

McGilchrist, I. (2009). *The master and his emissary : the divided brain and the making of the Western world*. New Haven: Yale University Press.

Mezirow, J. (1996). Beyond Freire and Habermas: Confusion a response to Bruce Pietrykowski. *Adult Education Quarterly, 46*(4), 237.

Mezirow, J. (1997). Transformative learning: Theory to practice. *New Directions for Adult & Continuing Education*(74), 5.

Miller, J. P. (2005, 2005). *Holistic learning and spirituality in education: Breaking new ground*, Albany.

Morrison, K. (1995). *Marx, Durkheim, Weber: Formations of modern social thought*. London; Thousand Oaks, Calif.: Sage.

Newton, I. (1730/1974). *New theory about light and colors*. M¸nchen: W. Fritsch.

Nielsen, J. A., Anderson, J. S., Zielinski, B. A., Ferguson, M. A., & Lainhart, J. E. (2013). An Evaluation of the Left-Brain vs. Right-Brain Hypothesis with Resting State Functional Connectivity Magnetic Resonance Imaging. *PLoS ONE PLoS ONE, 8*(8).

Nisbett, R. E. (2003). *The geography of thought : how Asians and Westerners think differently -- and why*. New York: Free Press.

Palmer, P. J. (1993). *To know as we are known: Education as a spiritual journey*. San Francisco: HarperSanFrancisco.

Palmer, P. J. (1998). *The courage to teach: Exploring the inner landscape of a teacher's life*. San Francisco, Calif.: Jossey-Bass.

Palmer, P. J. (2004). *A hidden wholeness: The journey toward an undivided life: welcoming the soul and weaving community in a wounded world*. San Francisco, CA: Jossey-Bass.

Palmer, P. J., Zajonc, A., & Scribner, M. (2010). *The heart of higher education: a call to renewal*. San Francisco: Jossey-Bass.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. New York: Basic Books.

Piaget, J. (1929/2007). *The child's conception of the world*. Lanham, MD: Rowman & Littlefield.

Piaget, J. (1950). *The psychology of intelligence*. London: Routledge & Paul.

Piaget, J. (1959). *The language and thought of the child*. New York: Humanities Press.

Piaget, J. (1965). *The moral judgment of the child*. New York: Free Press.

Piaget, J. (1973). *The child and reality; problems of genetic psychology*. New York: Grossman Publishers.

Piaget, J. (1976). *The grasp of consciousness: action and concept in the young child*. Cambridge: Harvard University Press.

Piaget, J., & Inhelder, B. (1969). *The psychology of the child*. New York: Basic Books.

Piaget, J., & Inhelder, B. r. (1969). *The psychology of the child*. New York: Basic Books.

Piaget, J., & Valsiner, J. (1927/2001). *The child's conception of physical causality*. New Brunswick (N. J.); London: Transaction Publishers.

Portes, P. R., & Salas, S. (2011). *Vygotsky in 21st century society: advances in cultural historical theory and praxis with non-dominant communities*. New York: Peter Lang.

Ptahhotep, Kagemna, Gunn, B. G., & Amenemhet. (1985). *The instruction of Ptah-hotep and The instruction of Kegemni: the oldest books in the world*. London: J. Murray.

Quinn, D. (1992). *Ishmael: A novel*. New York: Bantam/Turner Book.

Schrodinger, E. (1944/1992). *What is life?: The physical aspect of the living cell; with Mind and matter; & Autobiographical sketches*. Cambridge; New York: Cambridge University Press.

Senge, P. M., & Barker, T. (2008). *The necessary revolution*. Westminster, MD: Books on Tape.

Shor, I., & Freire, P. (1987). *A pedagogy for liberation: Dialogues on transforming education*. South Hadley, Mass.: Bergin & Garvey Publishers.

Stone, M. (1976). *When god was a woman*. New York: Dial Press.

Teresi, D. (2003). *Lost discoveries: the ancient roots of modern science -- from the Babylonians to the Maya*. New York: Simon & Schuster.

Thomas, L. (1974). *The lives of a cell; notes of a biology watcher*. New York: Viking Press.

Torres-Crespo, M. N. K., Emily; Pallansch, Lindsey. (2014). From Fearing STEM to Playing with It: The Natural Integration of STEM into the Preschool Classroom. *SRATE Journal, 23*(n2), 9.

Vimal, R. L. P. (2010). On the quest of defining consciousness. *Mind and Matter, 8*(1), 93-122.

Vygotsky, L. (1962). *Thought and language*. Cambridge: M.I.T. Press, Massachusetts Institute of Technology.

Vygotsky, L. (1966/2011). *Play and its role in the mental development of the child*. [S.I.]: Amazon Digital Services.

Vygotsky, L. (1979). Consciousness as a problem in the psychology of behavior. *Journal of Russian and East European Psychology, 17*(4), 3-35.

Vygotsky, L. (2002). Play and its Role in the Mental Development of the Child (Original publication: Voprosy psikhologii, 1966, No. 6). *2003*.

Vygotsky, L., & Cole, M. (1978). *Mind in society the development of higher psychological processes*. Cambridge, Mass. [u.a.: Harvard Univ. Press.

Warford, M. K. (2011). The zone of proximal teacher development. *Teaching and Teacher Education, 27*(2), 252-258.

Weber, K. (2012). Gender Differences in Interest, Perceived Personal Capacity, and Participation in STEM-Related Activities. *Journal of Technology Education, 24*(1), 18-33.

Wertsch, J. V. (1985). *Vygotsky and the social formation of mind*. Cambridge, Mass.: Harvard University Press.

White, J. L., Altschuld, J. W., & Lee, Y.-F. (2006). Cultural Dimensions in Science, Technology, Engineering and Mathematics: Implications for Minority Retention Research. *Journal of Educational Research & Policy Studies, 6*(2), 41-59.

Wynter, S. (2001). Towards the sociogenic principle: Fanon, identity, the puzzle of conscious experience, and what it is like to be "Black". *HISPANIC ISSUES, 23*, 30-66.

Young, T. (1804). The Bakerian Lecture: Experiments and Calculations Relative to Physical Optics. *Philosophical Transactions of the Royal Society of London, 94*, 1-16.