Science and Culture - Inalienable Co-determinants of Human Progress: Implications for Science Education and Administration

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***Abstract*— Science is a process of establishing the knowledge and understandings of the principles and dynamics shaping the interaction of people among themselves and with the natural world. Culture is an integrated system of shared beliefs, norms, values, and understandings that shape the way people live and interact with each other and with the natural world. These beliefs, norms, values, and understandings are in turn shaped by people's perception of their natural world. Philosophically therefore, both science and culture, presently and potentially, have the power to shape how people interact with each other and with nature. In this paper, the author explores the components of the common boundaries of science and culture as tools for human interaction among themselves and with their life-world. The author then makes a case for the inalienable mutual influences of science and culture, as co-determinants and co-drivers of human progress. Implications of this co-determinism for science education and administration are also explored.**

***Keywords*— Co-determinism, Culture, Human progress, Science, Science education, Science education administration, Science education policy, Science instruction.**

I. INTRODUCTION

Various definitions of science abound, from the perspectives of hard-core theorists in science, to the cross-content layman's perception of what science is. Adam Bly [1], in *Science and Culture*, defines science as "any study rooted in rigorous systematic methodology, evidence-based, persistent inquiry and criticism". In the context of this paper, one of the few definitions of science that comes to mind is the one offered by Shedon Gottlied [2:6], in a presentation at the Harbinger Symposium on *Religion and Science – The Best of Enemies and the Worst of Friends*, in Mobile, Alabama, USA, April 3, 1997 in which science was defined as:

> *An intellectual activity carried on by humans, designed to discover information about the natural world in which humans live, and to discover the ways in which this information can be organized into meaningful patterns.*

I add here that science is the application of these '*meaningful patterns'* to enhance (or sometime distract) human interaction with the natural world. This *'application'* extension of science is sometimes called *'technology'*. Science can also be viewed as a tool for visualizing and solving problems; establishing interconnections and relationships; and for reigniting and emboldening understanding of self and own environment. This also includes the understanding of the democratic process.

From these descriptives and definitions, and for the purposes of this paper, I define Science as:

> *A process of establishing the knowledge and understandings of the principles and dynamics that shape the interaction of people among themselves and with their natural world.*

From the above it is apparent that science is not, and should not, be limited to knowledge in medicine, biology, physics, engineering, technology, etc. We should also think of science in the realms of studies about life, reasons for poverty, society, human-human interactions, morality, the markets, economies, and other human philosophical, psychological, and sociological spheres. All of these are collectively called *Culture*.

What then is Culture?

To the intellectual schools on culture, the term 'Culture' is very difficult to describe and define without becoming convolutedly messy. Kroeber and Kluckohn [3] saw 'culture' as the "active cultivation of human mind". They opined that 'culture' is a platform for configuring the '*spirit*' that informs the whole way of life for a distinct group of people. Jenkins

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[4:6], citing Geertz [5], describes 'culture' as follows:

> ….. *there is no such thing as human nature independent of culture. Men without culture would not be the most clever savage or the nature's noblemen. They would be unworkable monstrosities with very few useful instincts, few recognizable sentiments, and no intellect; a basket case.*

In more recent times, culture has been described and defined as follows:

> *Everything that people beliefs and everything that they do that identifies them as members of a group and distinguishes the group from other groups* ; Lindsey, Robins, & Terrel [6:27].

> *The collective programming of the mind which distinguishes the member of one group or society from another* [7].

A more systematic analysis of what constitute culture may bring our understanding of 'culture' to better crescendo of comprehension. Jenkins in [3] identified four categories of the constituents of 'culture'. Culture, from individual viewpoint, can be seen as the perceived general state of mind, cognitive capability, and social disposition. This is obvious when we say that an individual is '*cultured*'. As a collective categorization, 'culture' can mean a state of 'collective cognitive development'. This is where 'culture' is seen as a measure of 'civilization'. Culture can also be seen as a social construct that shapes the whole way of life of a group of people.

Roshan Cultural Heritage Institute, Honolulu, Hawaii, USA [8] also describes the components of culture to include, but not limited to:

Language: As a medium of expression among a group of people.

Arts and Sciences: As another more advanced form of human expression.

Thoughts: As the ways in which people perceive, interpret, and understand the world around them.

Spirituality: As the value-system transmitted through generations for the inner well-being of humans, expressed through language, individually or collectively.

Social Activities: As the shared pursuits of happiness and meaning within a community, demonstrated in a variety of festivities and life-celebrating events.

Interaction: As the social aspects of human contact, including the give-and-take of socialization, negotiation, protocol, and conventions.

I expand Owens and Valesky [9], Philips and Wagner [10] elements of culture, to include the following:

Values: Core principles that members of group hold true and dear.

Beliefs: Opinions commonly held by members of a group on specific thoughts, issues, and situations, often without rigorous questioning of the basis.

Assumptions: Processes, practices, and procedures previously used that have worked effectively within a group and have become reflexively taken for granted.

Attitudes: The way a group responds to situations or issues based on what is perceived and believed to be reality and truth.

Behaviors: Collective dispositions of a group in the process of interacting among themselves and with others.

Rituals: Formal activities that are periodically performed by a group.

Traditions: Collection of inherited practices that have become acceptable manner of behavior.

Norms: Commonly accepted rules and regulations that define and guide what is acceptable and unacceptable behavior among a group.

Artifacts: Physical collectables that provide evidences of group processes and practices over time.

Reasoning from these descriptives and definitions, and for the purposes of this paper, I define Culture as:

> *An integrated system of shared beliefs, norms, values, and understandings that shape the way people leave and interact within a defined community*.

Therefore, science and culture can be seen to have the following united commonalities and differences:

(1) Both science and culture tend to find meanings in the nature of the mutual interactions of humans and the natural world.

(2) While science is a systemically *organized body of knowledge* focused on the nature of the interaction of humans with their environment, culture is an integrated but *diffused system of understandings* that guides the interaction of humans with themselves and their environment.

I will now explore this broad similarities and differences in more detail to establish the co-determinism of science and culture as drivers of human progress and the implications for science education and administration. This exploration will begin with a critical look at the convergence of science and culture from intellectual perspectives.

II. A CRITICAL LOOK AT THE CONVERGENCE OF SCIENCE AND CULTURE

It is difficult to proceed far on issues and questions relating to philosophy, science, and culture without an understanding of the full history of humanity as rooted in evolution Wilson & Dennet [11]. Evolutionary Biology, as originally explained by Darwin [12], in *The Origin of Species,* presents evidence for *variation* in the characteristics of individuals within a species. The process of *selection* then takes place where individuals, possessing certain characteristics within the species, are enabled to pass on the characteristics to the next generation in the form of *inheritance.* Sometime the inherited characteristics may be advantageous or disadvantageous. Where they are advantageous, the next generation becomes more adapted and thrive. But, where they are disadvantageous, they become ill-adapted and extinct [13].

By the same token Cultural Evolution impresses that there is considerable *variation* in terms of cultural diversity [14]. In Cultural Evolution, the process of *selection* also occurs. More resilient and favorable cultural traits are passed on to next generations in form of *inheritance* while the less favorable ones become diminished if not extinct. The *'inheritiability' of* advantageous cultural traits often show in the transmission of skills, beliefs, artifacts by traditional societies Bandura [15]; Whiten, Custance, Gomez, Teixidor, & Bard [16].

Also in phylogeny (the step-by-step biological process of evolution) members of a species enter as a 'primitive' form. After entering, they have two options; (1) they can use the process to step-up their game and emerge from it as more adaptive forms, or retrogressed as less adaptive forms and fade away during the process. Humans have constantly emerged in the evolutionary process in more adaptive forms. Each step of the interaction of humans with the environment produces '*more adaptive us'*. The more adaptive 'us' creates more adaptive sets of beliefs, ways of doing things, etc. In the process, cultural evolution occurs. Hence, cultural evolution can be regarded as a phylogenic process.

The framework below adapted from Futuyma [17], further demonstrates the relationship between Biological Evolution and Cultural Evolution. The framework illustrates the convergence in biological evolution and cultural evolution patterns. At the micro-level, population genetics, evolutionary ecology, and molecular genetics on one side parallels cultural anthropology, behavior culture/psychology, and memetics on the other. Likewise at the macro-level, systematics, paleobiology, and biodiversity on one hand parallels comparative anthropology, evolutionary archeology, and cultural anthropology on the other.

TABLE 1
FRAMEWORK FOR RELATING BIOLOGICAL EVOLUTION TO CULTURAL EVOLUTION

Biological Evolution		**Cultural Evolution**	
Micro Population Genetics	***Macro*** Systematics	***Micro*** Cultural Anthropology and Gene-Culture Coevolution	***Macro*** Comparative Anthropology
Evolutionary Ecology	Paleobiology (Study of Fossils)	Behavior Culture and Psychology	Evolutionary Archeology
Molecular Genetics	Biogeography and Biodiversity Studies	Mimetics and Neuroscience	Cultural Anthropology

Therefore, Darwin's concept emerges as a unifying idea and the basis for the *singularity* of all the platforms of human interactions with nature, including science and culture. Every human contraption, either in science and culture, stems from the *'tree of life'* with its roots in the evolutionary process of science. This is another reason why the concept of 'Evolution' is often very unsettling for some people as an inconvenient truth. Yet, the relationship between science and culture is so strong as to make the two inalienable, as co-determinants of humanity's present and future.

III. SCIENCE AND THE RELIGION AS A CULTURE

One of the most controversial areas of the connection between and science and culture, as inalienable co-determinants of human progress, is the interaction of science and religion. Before I proceed further, it is important that I explain what I mean by 'religion' in the context of this paper. By '*religion*', I mean the organized system of expressing personal beliefs in supreme power(s), often with others who hold similar beliefs, under specified rituals and codes of conduct. This is different from spiritualism; a set of innately held thoughts, opinions, deep questions, and beliefs in '*powers beyond the self*' and the wonderment of the influence of such powers on '*the self*' and nature. Sometimes, spiritualism can form the basis for a religion.

Biblical story tells us that the minds of Eve and Adam led to the rationalization for accepting the 'forbidden fruit' resulting in their ouster from Garden

of Eden. Adam and eve may have gone through the process of scientific questioning to arrive at a logic of eating 'the fruit'. This may be one of the reasons why religion seems to blame science as the culprit that led humans to commit the 'immortal sin'.

There were some intellectuals, like Oswald Spengler [18], in *Decline of the West* who believed that mastering nature with science leads to human hubris where humans may begin to see themselves as the all-powerful creator. They opined that, scientists are not rejecting the devil's tempting offer to make humans have dominions over all earthly contents, good or bad. Sometime, this school of thought seems to forget that after the '*Creator*' 'created the heavens and the earth', the first decree he pronounced was to grant humans dominion over everything on Earth. In practice, humans find it easier and more soothing to defer the causes of nature's unusual phenomenon to 'higher purpose', or 'celestial powers' than to think it through the complex and rigorous systemic probing lenses of science.

Science is founded on questioning, inquiry, self-criticism of beliefs and knowledge, etc. The understanding that any idea can be overturned at any time is central to science. Religion, on the other hand, seems to abhor questions. It stresses that abstract understandings should be taken just the way they are with only the '*Higher Power*' having the answers which may never be revealed to humans. We have seen, in history, the persecution of scientific philosophers, who the religious establishment believed were threatening the 'faith of believers' through 'explainable revelations' of some of the 'mysterious' works of the *Creator*. These conflicting toggles have stood in the way of allowing objective understanding of the mutual commonalities of science and religion (as culture) in shaping human life and handwork of the *Creator* in the process.

A critical examination reveals that this seemingly dichotomous conflict, between science and religion as a culture, is often illusory; based on the following reasoning. Religion also 'questions', but the answers are often not based on '*measurable physical evidence*' as in science. Religion questions and strives to find answers through the collective believe that the answers are only within the purview of the *Creator* and designated religious leaders. However, both religion and science are rooted in society and are mutual parts of human culture.

Some intuitive thinking in religion is rooted in scientific thinking as we look into the fields of 'Critical Science' and 'Critical Religion'. The Noah's Ark was a masterpiece in engineering and architecture. The Tower of Babel was an architectural stride, by humans, to attempt to build a skyscraper to reach the heavens. As a result of this, some schools of thought, in science and religion, believe that some religious devotees have justified the use of science to extol the *Creator* and re-create the presumed lost '*Edenic*' glory [19]. (Medieval Catholics and later Protestants believed that some religious devotees possess *divine spark*, given to them through 'supreme glory' to use on earth, to critically expand knowledge and understanding and to re-create *Edenic* conditions on earth. This is where we begin to see the active participation of many theologians in the process of situating science in religious contextual justification.

The Benedictine Order of the Monks and the Cistercian Order in the 12th century were well known for developing water mills and windmills. Puritan thinkers like Fancis Bacon [20], in *Advancement of Learning* wrote that scientific activities have as its ultimate end, the glorification of the *Creator*. Others like John Milton [21], in *Paradise Lost*, stressed that science in the hands of human would enable dominion over the earth, seas, and heavens, just like the *Creator* intended. Gregor Mendel [22], the father of hereditary genetics, is noted for his 'pea plant' experiments. He was a devout catholic monk who believed in the use of science to extol the wonders of the *Creator.*

IV. BROADER CONSIDERATIONS IN SCIENCE AND CULTURE AS CON-DETERMINANTS OF LIFE AS WE KNOW IT

The ability of humans to construct hypothesis, test hypothesis, simulate conditions, construct ideas, and build objects has immense bearing on culture [23]. In the context of science, nothing is absolutely new. What science does is to use existing 'constituents' and 'contents' of nature to change the nature and form of interaction between humans and the natural world. As science presents opportunities for humans to have new ways of interacting with their environment, so are opportunities provided for humans to explore new ways to express their beliefs, values, norms, use of language, etc. These are all components of culture.

Scientific processes begin with our imagination of what our environment and nature presents. Likewise, cultures are created through our imagination of what our environment presents, as modified by the influence of science. This is another point of convergence and marriage between science and culture as co-shapers of human life.

Cultures that are incapable of keeping pace with science often become retrogressed, marginalized, and sometime extinct. Likewise, scientific knowledge that is too deviant from prevailing culture gets delayed in acceptance and practice. Science is therefore

important in driving cultural change and sustenance. By the same token, culture is also important in driving the progress in science. Werner Sombart [24], in *Modern Capitalism: A Historical-Systemic Presentation of European Economic Life from the Beginning to the Present* believed that culture can shape science and technology. Culture can determine the pace at which knowledge in science is accepted. The works of Darwin, Copernicus, and Edison are examples of situations that demonstrate the constantly evolving interaction between science and culture.

The following illustrates how evolutions in science often lead to cultural change.

Example 1:
Darwin → Watson & Crick → DNA Structure → Understanding of Genetics → Bioengineering → Modern Medicine → Behavior Change → Cultural Change.

Darwin's theory of evolution led to Watson & Crick's discovery of the DNA double-helix structure providing the basis for a better understanding of genetics. This has led to explosion in bioengineering knowledge which is revolutionizing medicine as we know it. People are taking advantage of new ways to health, the concept of birth and living, and longevity. This in turn is leading to cultural changes in the way we define life and our interactions with each other.

Example 2:
Copernicus → Astronomy → Understanding of our Planet → Flights → Space Exploration → Satellites → Information Technology → Cyber and 'Cloud' Communication → Information Mobility → Information Ubiquity → Social Media →Digital Social-Networking → Behavior Change → Cultural Change.

Copernicus' foundation work in astronomy led to better understanding of our Planet/Solar System. This provided the basis for inquiry into flying and space exploration. Now we launch satellites into Earth's orbits leading to boundless expansion in information technology, communication, communication mobility, and digital social-networking. This is having profound influence on human behavior and the nature of our interaction with each other with boundless effect on cultural change.

Science as Technology and Culture

Science was the basis of the Industrial Revolution. Since the beginning of the Industrial Revolution, humans have lived in the age of combination technology innovation. In the 19th century, the combination was steam engines, wheels, gears, belts and pulleys. In the 20th century the combination consisted of internal combustion engines, electricity. In the 21st century it is computer technology, electronics, and micro-chips, information ubiquity, etc.

Thomas Hughes [25], in *Human-Built World* stated that humans have used the science of technology to transform our physical environment into one full of artifacts and systems that play influential roles in shaping our culture. Science, as technology, produces goods and services that consumers respond to and enthusiastically interact with. This in turn influences culture. Through the science of electricity and, light cities like New York, Berlin, London, Paris, Tokyo, Shangai, Seoul, Barlin, Los-Angeles, Lagos, Vienna, etc., became fortresses of high culture.

Human history abounds with celebrations of the transforming power of technology. It is widely believed that humans can express virtuous values (a component of culture) as they create and evolve the human-built world. Hughes [25:50] eloquently expressed the influence of science as technology on American culture in the early 20th century:

> *Electric signboards and electrically lit department-store windows attracting middle-class shoppers clothed in machine-made dresses and suits; telephone networks linked businesses and neighbors; the brightly lit marquees of theaters illuminated the faces of people excitedly seeking diversions; railway stations and subways witnessed the influx of people from the countryside escaping traditional culture and seeking modern novelty .*

I have re-written these words of Thomas Hughes in the context of the 21st as follows:

> *Digital effects are everywhere. Humans are connected and wired to different types of digital devices; within their now 'natural' world. Computer links and 'cloud' communication connect persons, businesses, and nations all over the world at speeds faster that of sound. Computerized automobiles, magnetic levitation high-speed trains, and jumbo-jets move people around the world and across cultures at immense speeds. Cultures and sub-cultures are being created and evolving as quickly as wired and 'cloud' communication move across national boundaries; encouraging movement towards* ***global cultural singularity****. Who says that science and*

culture are not inescapably wired and linked?

Technological Cybernetics, Communication, and Cultural Evolution

In the 21st century, the technological innovation combination bearing great influence on human culture are the software applications, connectivity interfaces, interactivity platforms, social medial, cloud technology, bites, pixels, etc. People and society are drawing on various innovative Modern Technology Socialization Platforms (M-TSPs) such as e-mail, chat, blogs, wikis, twits, u-tube, Facebook, Voice-Over-Internet Protocols (VOIPs), 'cloud computing', Skype, Linkedin, internet search engines, etc., to change the nature of interaction between people in ways that have profound influence on cultural underpinnings, cultural understandings, cultural exchanges, cultural acceptance, cultural adoption, cultural assimilation, cultural integration, and cultural evolution.

In the sphere of cultural understanding, M-TSPs have broken down barriers in terms of both geographical loci and learning access to cultures across group boundaries, both locally and internationally. A click of the mouse or a tap on the button of a computerized device can instantly connect individuals to various cultures and sub-cultures providing pertinent, and sometime interactive, on-demand information for real-time diversified cultural experiences. M-TSPs have also influenced cultural exchanges. People who are separated by great distances can now instantly exchange cultural experiences through pictures, movies, digital memoirs, real-time video streaming, etc. in ways that allows the exchange of large volumes of cultural information on micro-chips or through *technology clouds* without the expense of physical travel. This has tremendous impact on cultural evolution.

The rapidity and volume of cultural exchanges, made possible by modern M-TSPs, have also enhanced the revealing of areas of cultural commonality; despite obvious and perceived differences. This is contributing, in no little way, to the promotion of cultural acceptance. Among the younger generation, the ease of access and the increasing ubiquity of cultural information through M-TSPs makes it more possible to adopt compatible aspects of other's cultures; that would have otherwise been unavailable. This is evident in the increasing convergence of cultures in spheres of literary arts, entertainment, expressions, and socio-political awareness and beliefs.

Given the advantage of prior knowledge of other's cultures, made possible through M-TSPs, the steepness of the learning curve, associated the process of cultural assimilation, is lessened as people move across cultural boundaries, both physically and virtually. This is helping to reduce the initial anxieties associated with cultural assimilation processes.

M-TSPs, logically promotes interactivity in cultural experiences. Cultural interactivity provides the foundation for cultural integration through the principle of what I call '*cultural give-and-take'*. This principle posits that there are aspects of one culture that can be used to reciprocally inform and educate another culture for the mutual improvement of both.

All of the above are contributing to *convergent* cultural evolutionary processes which is slowly, but gradually, leading to *cultural singularity*. This is another example of the co-determinism of science and culture on human progress. The possible outcome of this leads to the question; In the co-determinism context, does science dictate '*cultural progress'* or does culture dictate *'scientific progress'*?

V. DOES SCIENCE DICATE 'CULTURAL PROGRESS' OR DOES CULTURE DICATE 'SCIENTIFIC PROGRESS'?

The answer to this question is simple; they are mutual co-dictators of each other, depending on the context. As explained, science has always shaped the way humans interact with each other and with their environment. This interaction in turn produces changes in the way humans perceive their *life-world* and hence their perception of the changes in their values, beliefs, assumptions, attitudes, behaviors, rituals, traditions, norms, and artifacts which, cumulatively, produces changes in cultural practices and ultimately cultural progress. Computer technology is transforming human environment and education as we know it. Information age is creating new human identity.

Culture has always had scientific and technological consequences. Human values, beliefs, assumptions, attitudes, behaviors, rituals, traditions, norms, and artifacts (collectively called culture) have been shown to sometime impede scientific progress. Culture has sometime portrayed science as the *'stranger'* coming to *'pollute culture'*. This is the *cultural Puritanism* view-point.

From post-modern resistance perspective, Sandra Harding and Robert Figueroa [26] argues that western education tends to portray science as *'western knowledge'* and in the process tends to draw a line between science, as a '*western thing'*, and as '*western culture'* in the belief that only western knowledge can produce such a mark of superior intellectual construct as science, and only such

knowledge can escape the trappings of religious and cultural interferences that infest other knowledge/cultural systems. This is an *exceptionist* and *triumphalist* position.

In more practical context, some people are resistant to modern social-media technology on the basis of personal beliefs in the primacy of individual's privacy. Some segments of society are resistant to embryonic stem-cell research on perceived moral grounds. At the same time, The Vatican is now getting into the stem-cell research arena. In the later part of 2011, The Vatican pledged funding for research in the area of adult stem-cell, to divert focus from the controversy over research on embryonic stem cells.

The bottom-line answer to this question 'which is the egg and the chicken between science and culture?' is that:

> *There is culture embedded in **science as an enterprise** and there is science embedded in **culture as a practice**, when viewed from a critical perspective.*

VI. IMPLICATION FOR SCEINCE EDUCATION AND ADMINISTRATION

Seeing science and culture as co-determinants of human progress has implications for science education and administration. The implications can be considered from the perspective of defining the goals for science education, science curriculum, science instruction, assessments in science, and administrative policy considerations on science education.

Implications for defining the Goal for Science Education

The goal for science education is to attain literacy through basic understanding of the nature of the world around us; how we interact with it; how we interact with each other; and its impact on our individual and collective lives and cultures. The goal for science education is best summarized as:

> *Over the course of human history, people have developed many interconnected and validated ideas about the physical, biological, psychological, and social worlds. Those ideas have enabled successive generations to achieve an increasingly comprehensive and reliable understanding of human species and its environment. The means used to develop these ideas are particular ways of observing, thinking, experimenting, and validating. These ways represent a fundamental aspect of the nature of science …* (American Association for the Advancement of Science).

This goal definition for science education clearly extol the interconnection between science, the world around us, and the society and the cultures we live in. The goal definitions also portray the importance of seeing science education beyond the domains of biology, chemistry, physics, mathematics, and technology. The goal indicates that science educators extend knowledge in the discipline to include the understanding of the connection between science and culture as a part of the world around us.

Implications for Science Curriculum

Curriculum is a developmentally appropriate guideline which defines learning expectations and outcomes relevant to learners and aligned to societal values beliefs, and educational goals while addressing content specific knowledge. A curriculum must build new ideas from exciting ones based the prior knowledge and skill context of the intended learner *(Harold Pratt, President, NSTA, 2001-2002 in Atlas of Science Litercay; Project 2061).* The prior knowledge and skill context is, in turn, a factor related to the cultural context of the learner. Therefore, consistent consideration must be given to culture in the development of science curriculum to encourage wider participation in science literacy focused on science as inquiry, especially in the following domains:

The Nature of Science: This domain comprises of the world view of science, science and human society, and science as an enterprise.

Science and the Human Organism: Which should include knowledge in human identity, human development, human learning, and health (both physical and mental).

Science and Human Society: To include cultural effects of science, science and social change, science in political and economic systems, science of social conflict, critical cultural studies, and global interdependence.

Science and the Designed World: To include knowledge in technology, architecture, communication, information processing and dissemination.

Implications for Science Instruction

Science instruction should be enriched by making cultural connections to concepts taught and presenting scientific ideas, research, discoveries, and innovations in cultural contexts. Doing this should have the effect of dampening the perception of science as the intruding *stranger* and *pollutant* of

cultural purity. It should portray science as integral part of cultural understanding and advancement. It would also help to bring science to the daily *life-world* and reality of the learner.

Implications for Assessment in Science

The ultimate benefit of science knowledge is its application in the interactive interface with and support of human activities. Extending authentic assessments in science education to the application and production of solutions to human cultural challenges and experiences would move science from the perceived realms of *intellectually-elitists isolation* to the open arena of the *commons* where everyone would feel empowered to participate and contribute to the body of this noble body of knowledge.

Implications for Science Education Administration Policy

It is ironic that despite the extremely noteworthy contributions that science has made to human progress, the general public, including youths, is skeptical and often *suspicious* about knowledge and understandings in science. Various authors like American Association for the Advancement of Science (AAAS) [27]; Phillips, and Wagner [28] have lamented the attitude of the general public, and especially youths, to science. Published research [28] shows that younger children in elementary schools are initially very enthused about learning science. Unfortunately, as they grow older and progress to higher grades, their interest in science begins to wane. This could be as a result of increasing impact of anti-science cultural innuendos pervasive in the society; from religious teachings to the posturing and positioning of science as *that strange subject*. Students become increasingly unable to make the connection between science and their cultural experiences.

As students make progress to higher grades and to universities, recruiting them to become science practitioners becomes a daunting challenge. This is more so in the domain of science education certification. In the United States, it is not only difficult to recruit students to train as science teachers; even when they finally oblige, they rarely stay in the teaching profession after graduation, despite encouraging financial incentives.

The practitioners of science, science professionals, and science education policy-makers have a large share in the blame for this situation. Often science professionals position and posture science as an *elitist knowledge domain* above the *common-person's cultural understandings and practices*. They seem to forget that the applications of science often dictate cultural practices and cultural practices often dictate which knowledge of science become extolled. A critical examination of science curriculum, instruction, assessment, and evaluation, in the context of ensuring the *real* connection between science and culture, as explained in this paper may go a long way in promoting science as the attractive enterprise it is supposed to be to the general public, and especially to up-coming generations.

VI. CONCLUSION

Since the beginning of our *life-world*, as humans, science has played significant role in the understanding and shaping of the nature of the interaction of humans with their environment. Science has been the driver of each of the milestone stages of human social and economic development; from the agrarian revolution, the industrial revolution, the age of electricity & electronics, the digital age, to the current information revolution age. Each of these stages has had, and continues to have, noteworthy impact on human cultural processes, practices, and change.

Also, existing cultures often dictate the way science knowledge produces applications, innovations, and inventions to influence how humans interact with each other and with their environment. These scientific applications, innovations, and inventions in turn impacts cultural practices which in turn produce changes in culture. This has been the continuous interdependent nature of science and culture as co-determinants of human progress.

Sometime, the debate arises as to what the future holds for culture in a world with various combinations of humans and scientific innovations, inventions, and applications. This debate is not new. It has always been the case in human history. Humans have an immense capacity for authentic and critical thinking. In a way, we are using science to challenge ourselves in a continuous loop-process of *second-order* and even *third-order* thinking. As long as we constantly remind ourselves that there is an in-alienable tie between science and culture, as co-determinants of human progress, we should be ahead in ensuring that whatever science produces to inform culture, can also be used by culture to inform science for the mutual benefit of the two and for the progress and advancement of mankind.

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