How to Make Sense of Complex Technical Issues

Can Cultural Ideas Influence the World of Science?

To provide students advanced critical thinking skills to navigate through the complex worlds of science, cultures, and beliefs by focusing on real-world knowledge and taking into consideration the many aspects of human biases and paradigms

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Abstract

This thesis outlines a logical thinking system for science and technical students to help them recognize, understand, and manage systemic biases that may intrude into the presentation of scientific topics. It focuses on how details reported by educators and media (social, news, opinions, technical documentaries) may cause non-experts to misunderstand complicated or complex scientific and technical issues. The work described in this report covers topics of human biases and scientific paradigms, along with the question: Can cultures and partisan ideas influence aspects of the scientific world? It includes the fundamentally different way the applied sciences (e.g.: engineering, technology, certain medical procedures) determine facts as compared to the methodologies used by scientific research scholarship.

A method is proposed to classify sciences based upon the procedures they use to both determine and verify their evidences. "Cultural Sciences" - those sciences that could possibly be affected by cultural ideas, systemic and individual biases, scientific paradigms, and research funding – are discussed. Details on how scientists could voluntarily establish their impartiality and manage their biases are provided. Included is a section on science education with the goal of showing students the need for advanced critical thinking skills and how to navigate through the complex world of science, cultures, and beliefs. Data on three examples of current-day cultural sciences are presented to illustrate how interested non-professionals can establish the dependability of scientific and technical findings. The main keys are to focus on what is known for certain (called here: high probably knowledge) and to take into consideration the many aspects of human biases and paradigms.

Discussion & Analysis

The applied sciences, including engineering, technology, and medical procedures, have made dramatic advances in real-world knowledge and progress over the last century. During the same period, scientific research has made similar extraordinary discoveries. However, what is often hidden by the exciting and attention-grabbing scientific research breakthroughs is that unforeseen and imponderable questions* come to light when related conclusions are resolved.

* Of the many examples a selection of unresolved scientific questions are the nature and aspects of the many findings of the social sciences, human consciousness, light, gravity, chaos theory, dark energy, dark matter, quantum mechanics, self-organization, the limitations of computing power, origins of scientific laws, etc., etc.

The key difference between technical questions and the modern world of scientific research is how each acquire their evidences. The former learns by trials, errors, and successes. Nineteenth century bridges and tall buildings either stood up or fell down, early aircraft and computers worked satisfactorily or crashed, pioneering medical patients either lived or died, innovative machines and products functioned as designed, failed too soon, or cost too much to build. Technical knowledge is unquestionably achieved *only* by practical experience. It builds upon what is known for certain - or has an especially high probability of being true (high probability knowledge). Numerical analytical methods (mathematical theory and computer-based solutions) were developed in unison with, and received input details from, the practical experience data.

The original sciences, for the most part, laid the foundations and allowed the flourishing of engineering and technology. But, foundational chemistry and the physics of thermodynamics, electromagnetics, mass-energy, and quantum mechanics were essentially completed over a hundred years ago. At that point research science experienced a shift in its traditions, such that the vast majority of modern-day science no longer functioned by the use of refutable laboratory tests and applied mathematics.

Science changed for the legitimate purpose of focusing on questions that were multifaceted, less explicit, and which could not be supported by unqualified applied mathematics. Even for apparently straightforward matters such as: is coffee or alcohol neutral, advantageous, or a hindrance to human health, a straightforward theory is awkward to formulate. Such questions require numerous ponderable qualifications before they can be addressed. In the above example: the consumer's daily intake, their basic health, their genetics, and a range of lifestyle issues are logical variables. Modern science became almost exclusively "complex science", as compared to the foundational laboratory and mathematically based sciences of the previous five centuries.

To make this complex type of research manageable various assumptions and specific ways of looking at and solving a problem had to be made. Results thereby became contingent upon those assumptions and hypotheses. While conclusions are presented to the public as definitive science, often established by the use of "indisputable" sophisticated technical instruments, they could also be portrayed as being an amalgam of pre-selected research methods and assumptions, particular ideas, and educated inferences. Findings are rarely absolute but are either "plausible and uncontentious" or alternativly "not generally acceptable". When researchers, or their peers, discover uncomfortable anomalies, new data, or question the initial assumptions or approach to the research, then work on the topic would continue.

This thesis addresses two central questions arising from the above preliminary analysis of science: 1] Are any of the conclusions of the "cultural sciences" (see description below) affected by human biases, scientific paradigms, and/or selective research funding? 2] If they are, how should individuals manage and understand the publicly available scientific information and data?

Cultural Science

All scientific research has a cultural objective. It is the discovery of the objects, structure and behaviour of the natural world so findings can be used to generally advance the health, wealth, and enrichment of humans. Cultural sciences are distinct as they can employ methods which are unverifiable and unfalsifiable, or specific limits are placed on their possible conclusions. Sciences should ideally be divided into distinct categories depending upon the nature of their evidences and the degree of influence that biases, paradigms, and funding could *possibly* have on the findings. Proposed categories are: the *foundational* or technological sciences (physics, chemistry, applied mathematics, and the explicit observational and laboratory sciences), the *complex* sciences - topics that require certain assumptions to proceed with the work, and thereby cannot be resolved by direct observation, mathematical means, or established in a fully controlled and replicable laboratory; and the *cultural* sciences, the branch of complex science which may have explicit social goals. This thesis will focus on the cultural sciences.

When scientific questions touch on cultural or possible partisan ideas *and* useful solutions are considered by the culture to be important, scientists may be indirectly encouraged to establish particular details and solutions. Unlike technology or the laboratory / mathematical sciences, cultural sciences do not progress exclusively by trial and error or real-world successes and failures. The findings of complex issues are typically more tentative and less easily understood. So, there is significant pressure for scientists, or their advocates, to be influenced by a need to convince other people that their scientific conclusions are reliable and true. Fortuitously, there is a distinct scientific attribute that mandates cultural sciences be classified separately from other types of science.

Cultural sciences routinely break the most untouchable feature of the scientific method. This scientific gold-standard was established by experience as the best way to overcome systemic and other biases. Rather than applying this dependable approach - that demands every effort shall be expended to attempt to prove a hypothesis is *wrong* - cultural sciences tend to assign an inordinate amount of resources gathering data, not only to corroborate a theory, but to also ensure it is *perceived* by the public (the culture) as being true.

Systemic Biases

The many characteristics of human and group biases have been well researched both historically and recently. Observations about biases indicate they can be reflexive, can be virtually imperceptible to the perpetrator, and follow some basic behavioral laws. The most notable being: 1] Bias is triggered by reliance, or trust, on a person's or group's paradigm (details in the following section). 2: Personal biases cannot be effectively eliminated (Kahneman); 3: Bias is independent of intelligence or information (Stanovich); 4: Bias is independent of values* (empirical); 5: Bias is positively correlated to emotions, including the emotional need to influence and make judgements (implied: Mercier/Sperber); 6: Bias is positively correlated to a lack of humility (the Over-Confidence effect);

* This does not imply bias would not, in theory, be controlled by specific moral principles. But this law presumes the *application* of any "value" will always involve biased interpretations and judgments.

There are numerous well-known systemic biases that relate specifically to scientific research. They include: Publication Bias, where the conclusions of a study can influence the decision whether to publish the work, or not; Focusing Bias, where different degrees of reliance are placed on one piece of data and less on other data; Confirmation Bias, where a conclusion confirms what is already thought to be true; Bandwagon Effect, where a belief is held as a fact because many peers hold that belief; Omission Bias, where conflicting or anomalous evidence is omitted, avoided, or restrained; Outcome Bias, where an opinion is formed by features of its expected outcome, not on the quality of the data, Exposure Effect; the tendency to believe a fact based upon familiarity or exposure to the idea; Framing Effect, the tendency to present true information in such a way to produce a particular opinion in the greatest number of people; and Experimenter's Bias, the tendency for an experimenter to unconsciously bias behavior or opinions of participants in a social-science study.

Scientific Paradigms

Paradigms explain the fascinating issue of why humans, and groups, are essentially powerless to recognize their own biases. The word was popularized in the early 1960s by physicist and philosopher Thomas Kuhn in his book *The Structure of Scientific Revolutions.* Paradigm are essentially "assumptions" that we don't or can't question or doubt. They are axiomatic "truths" or deep-rooted principles we instinctively accept or reject. Paradigms *permit* biases and beliefs to form, not from the intrinsic quality of any underlying science or information, but from: 1] its *benefit* to a particular belief or purpose, or 2] the degree of trust, or distrust, people or groups have in the (perceived) *source* of the information. Paradigms thus pre-select, or bias, the range of possible answers to a question. If one's paradigms are unexamined or inappropriate, then bias will result. Virtually by definition people or groups' obsessions, indoctrinations, or experience of psychological trauma can trigger inappropriate paradigms.

Scientific paradigms add to the above list of general biases. They are the (biased) assumptions and (biased) methodologies that are "unconsciously" judged to be legitimate or illegitimate and under what circumstances exceptions are allowed.

Paradigms are little discussed in our current culture, yet they form the most dominant of the behavioral laws of bias. Fortunately, the issue can be condensed into one straight-forward question. Are the methods, probabilities, logic, and standards that scientists (or individuals) use to accept a theory *identical* to the methods, probabilities, logic, and standards used to reject any competing theory they *subconsciously* fail to value?

Research Funding

Technical and scientific work, like most other significant human endeavors, requires funding. There are few independent scientists with the circumstances and funds to carry out serious scientific work today; and when they do their work still needs to find a publisher and for the results to be widely disseminated. While overall, corporations provide more funds for science than governments for *all* scientific studies, the cultural sciences are primarily funded by governments and a few large foundations. Funds are either supplied by governments through the various national scientific bodies, universities, or indirectly through tax strategies and other incentives. Research organizations, including universities, typically submit proposals for funding; and the proposals can be framed, especially for cultural issues, to attract funding based upon an understanding of the known goals of the funder.

The above, along with other scientific biases, make the funding system vulnerable to the control of a group which may have specific cultural interests. The conclusions from scientific proposals can become self-fulfilling prophecies as a result of these, so called, Funding Biases.

Cultural Sciences & Impartiality

Scientists do not typically acknowledge the issues of biases, paradigms, and funding. They simply assert their profession is free of any possible bias. Their confidence is based upon: 1] reliance on the scientific method, 2] the use of a peer review system, 3] the requirement that experiments shall be capable of being replicated, and 4] extant internal quality assurance procedures. These items will be assessed:

1] The scientific method is not, as is often assumed, a fixed entity. Current complex and cultural sciences have a significant range of practices that are considered legitimate. For example applied mathematics is rarely used; and is replaced by statistical methods or theoretical math, neither of which is definitive; there is a wide range of ways science can discover evidences outside of a laboratory often with the word *observation* used in place of the word *inference;* testing does not mean fully controlled tests; predictions are typically narrative explanations; and even underlying logic is managed by the definition of acceptable paradigms. Finally, the scientific method's main feature of seriously attempting to refute a theory is never seriously used for "accepted" cultural theories. 2] The peer review process relies upon humans *not* being biased, with its main purpose being to catch procedural errors and not concept errors or omissions. The system is rarely opened to those known to have significanly different views, so it cannot be judged to be a probative system. 3] Replication relies upon assumptions and paradigms being identical to the original work. This results in any biases being *recycled.* Also, studies have shown a significant number of social science studies *cannot* be replicated. 4] While specific scientific experiments and tests *are* subjected to internal quality programs, primarily it is procedures that are controlled, not the use of broad thinking processes.

In summary, complex science practitioners have never demonstrated *scientifically* their research operates with a fixed set of explicitly designed rules to prevent biases insinuating into their work. The profession needs demonstrable impartiality; and it is unclear why historians and philosophers of science have been insufficiently vocal on this issue over the last half-century.

Advanced Critical Thinking

This section will explore how the critical thinker, as a primary stakeholder in the cultural sciences, should respond to the absence of any effective prescription to ensure scientific impartiality. On the assumption that internal reform of the cultural sciences will not occur rapidly, the first step is that a minimum impartiality benchmark be established. This is vital in order to define the current predicament in science, and how to resolve it.

To navigate through cultural science issues, it is essential to be fully aware of the different classifications of science, the importance of never violating high probability knowledge, and the biasing pressures that paradigms place upon people and groups.

Method to Establish Impartiality

A voluntary solution is suggested for all complex scientific work, especially those with a social or cultural goal. As part of an appendix to any report the author(s) should be encouraged to include a disclosure statement. This statement should detail the steps taken to ensure the research was carried out impartially. It would allow a well-informed reader to establish the work's impartiality.

This proposed voluntary "impartiality statement" should address the effects of the known human biases and paradigms (as discussed here). The following points, based upon the findings of philosophers of science refined over the five hundred-year history of modern science, would elevate the reputation of science to many serious thinkers. These items should be provided:

1. Details of the research carried out, if any, which was specifically designed to *disprove* the hypothesis or conclusion.
2. Details of independent replication work, if any, that was carried out for all or any part of the work.
3. Details of the assumptions, paradigms, or assertions of truth, upon which the conclusions rely – other than the foundational assumptions of science [e.g.: There are consistent laws of science throughout the universe; humans are capable of understanding them; and they have not changed over time].
4. A list of the anomalies discovered during the research work; along with their possible relevance and alternative conclusions;
5. The sources or details of the boundary conditions and variables used in all supporting mathematical models.
6. The sources of funds for the research. If the funds, in whole or in part, were directly or indirectly received from a public source, all the raw data shall be readily available to the public; and not treated as the intellectual property of any research entity or person.
7. Names and contact information of the formal peer reviewers.
8. A list of other verifiable steps taken to ensure research impartiality.
9. An affidavit regarding the following:
    - that all data collected has been disclosed as recorded; with data not used in the conclusions clearly identified;
    - identical standards of proof and logic have been applied for all processes required to formulate the conclusions;
    - the abstract, discussions, and conclusions of the report are fully supported by the data and findings.

The above disclosure would allow an informed user to consider its impartiality and dependability. To the extent that a report fails to comply with this logical voluntary procedure it should be interpreted by a critical thinker as a direct acknowledgment that its conclusions will contain errors or omissions; and that the conclusions should be interpreted as paradigm affected conjectures. The questions also illustrate the approach an advanced critical thinker shall consider when analyzing the cultural sciences. The next section provides similar aspects from the point-of-view of a stakeholder in the world of science.

Bias Management Tools

Specific steps can help individuals think with less bias and enable them to recognize biases more readily in others. A jury cannot properly consider a case by deliberating evidence from the prosecution and ignoring that supplied by the defendant (or vice versa), so for cultural science issues, evidence from all sides of a topic *must* be evaluated.

But without an acceptable impartiality statement, any biases in the cultural sciences, irrespective of its conclusions, may appear difficult to recognize. Fortunately, the level of bias in scientists, and their well-informed advocates in the media, can be appraised by asking oneself the following five groups of hypothetical questions about their content and style. These key flags (there are others, but the following are the most probative) expose whether a writer or speaker for a particular point of view communicates in an appropriate and scientific way. This approach should be used irrespective of whether you currently favor, oppose, or have no particular views on a topic. Directly comparing the content and style of experts with conflicting points-of-view is the most effective procedure.

1. Do any statements contravene, or fail to mention, relevant high probability knowledge? Is the information framed carefully, and is it logical and non-circular? Is it scrupulous and precisely follow an established scientific method? Is the evidence current, accurate, and not been discredited? The following points assist in addressing these questions.
2. Are the conclusions presented as being totally *obvious* with little to no arguments accepted against their viewpoint? The claim of obviousness typically relies upon the use of a lower standard for proof to support an issue and a higher, or different, standard for competing issues.
3. Are the conclusions narratively asserted as being true, with little support from high probability knowledge? Are key pieces of data avoided or asserted to be unscientific or irrelevant without evidence; as compared to acknowledging any anomalies*.
4. Is the presentation assertive by the use of a style that could confuse or overwhelm, with the apparent goal of having listeners or readers concede the expert is correct; as compared to acknowledging other peoples' specialty knowledge and trying to teach, clarify, and assist understanding? Are emotive facts or empty phrases used to make the topic easy to accept yet difficult to logically understand. Assertiveness could be said to be the art of selling biased opinions as facts.
5. Is the presentation judgmental of those who sincerely disagree? Does it unreasonably disparage the work of others who hold different conclusions, rather than concede their conclusions could possibly have some merit? Does it demean other scientists rather than express magnanimity?

* See the examples in the following three examples.

Examples of Three Cultural Sciences

This section presents three examples. They are included to underscore the preferred way to make decisions regarding complex scientific topics. This method was devised by applying a similar process to that used by the applied sciences by listing high probably knowledge about the topic. Those points must then be held in mind to ensure biases, paradigms, and assumptions do not disregard these *known* facts, *or* result in conclusions that breach those facts. Overt biases have been observed in virtually all cultural-type sciences including: many of the social sciences and animal population studies; even the analysis of sports performances in various groups. But the selected topics are: sustainable energy supply management, the theory of evolution, and the earth's changing climate. These topics are often controversial as both the science itself, and the way it is promulgated by the science news and documentary media, are often alleged to use methods that fall short of the scientific method. They are typically presented with unqualified denial that bias is involved in the underlying science.

The points raised in the following three sections were selected as they explicitly address evident errors or omissions in the cultural presentation of scientific data. The list does not include facts that *support* the cultural interpretation. It is asserted here: the high value of a sustainable and pollution-controlled energy supply; the directly observed morphological variations within species and the potential pseudogene issues; the significant percentage increase in atmospheric carbon dioxide and the increase in atmospheric temperatures recorded since the late 1970s. Those facts are generally well known and fully accepted.

Energy Supply Management

Energy supply management is primarily a technological issue. However, it is included here because the topic is broadly misunderstood, and it depends upon scientific research and data. From a review of the top pages of an internet search it is observed that virtually every website about energy use and supply, including media blogs, provides confusing or misleading information asserted as facts. The keys to solve these situations are to focus on high probably knowledge and to detect scrupulous science over muddled or misrepresented data by evaluating whether bias is involved. Provided impartial data is used, a database management system should be able to organize and manage the public energy supply. It could provide updatable conclusions regarding infrastructure and other capital costs, unit power costs, sustainability, and emissions data for various technological and resource scenarios.

1] No public energy resource can be considered to be totally free of cost or to be fully sustainable (as wind and solar often are), as *every* resource requires infrastructure energy along with mined materials and associated energy outlays, before it can conveniently reach consumers. 2] When a public energy resource is supplied intermittently, such as wind and solar, it must include an analysis which includes realistic efficiency data, energy storage solutions, down-time effects, backup systems, maintenance issues, and infrastructure systems along with real-estate costs. 3] Hydrogen is typically not an energy source but an energy storage and transportation system similar to a rechargeable battery where the energy can be produced either with *or* without carbon emissions. 4] The efficiency of an engine/motor system to convert an energy resource into useful work shall be appropriately determined. Efficiencies are continually being improved. 5] The term "hybrid car" is ambiguous. A plug-in hybrid has energy input in two forms, but other "hybrids" are internal combustion cars with "battery performance enhancements". Advantages are realized from the battery's energy capacity (kW-h or MJ) and maximum power (kW), the computer software's management system and the electric motor/generators and their controls. Enhancements include city driving fuel economy reaching highway driving levels by use of energy recovery and conservation systems; four-wheel drive without a heavy drive shaft; as-needed bursts of increased power; and mechanical and electrical power features without the IC engine running. 6] Different and constantly changing tax rates, carbon taxes, and various cost structures between energy sources and products, along with consumer rebates, and other corporate financial incentives, explicitly and fundamentally mislead the public and thwart a proper and long-term understanding of the energy cost and other issues. 7] Affordable and readily available energy is indispensable to modern-day humans. It is similar to the cultural goals of scientific research – to advances the health, wealth, and enrichment of all humans irrespective of where they live.

Evolution Theory

Evolution theory is disseminated by scientists, and much of the information media, with vigor and repetition. The theory is never seriously questioned. The evidence, combined with a grasp of scrupulous science, makes it is simple to evaluate whether bias is involved. Using the experience method of technological sciences, outlined in the discussion section above, there are a number of facts we know for certain about complex life that plainly test the current formulation of evolution theory. Just six, taken together, are sufficient:

1] DNA (a thread-like chain of organic molecules that carry genetic instructions used in the growth, development, functioning, and reproduction of all known living organisms) located in in the nucleus of essentially all living cells, comprise an intricately constructed digital code and integral decoding system, of immeasurable complexity and high precision. Evolution theory has yet to logically explain the origin of this information rich language. 2] *Numerous* other origin events are still unresolved, such as: oxygenic photosynthesis, body plans, and sexual reproduction. 3] Laboratory experiments on rapidly generating fruit flies, and other non-microorganisms, have been devised and carried out to fast-track mutations which were then manually selected, to represent the evolution process. The results of decades of this extensively accelerated simulation revealed only observably neutral or negative changes developed. No incipient new body plans or discernable survivability features developed. 4] Evolution in non-microorganisms has never been directly observed to occur, and the mathematical probability that it did occur as currently described, is beyond improbable for an impartial scientist. 5] One piece of evidence given to support evolution is that *nothing* makes sense in biology if the importance of the theory is not recognized. But engineers have discovered (biomimetics) numerous examples whereby replicating the details of certain living creatures gives rise to innovative and highly energy efficient solutions. As a result, the theory becomes: survival of the fittest not only developed all life but did so in a particularly high-tech way, as distinct from the formation of a chaotic assortment of components, as would be predicted by the current theory. The claims of natural self-organization are also restricted by the same logic. 6] The immense amount of scientific support for the current theory is often not an explanation but an account of what would have been *necessary if* evolution occurred. Circular claims such as this fail the benchmark for appropriate science.

The Earth's Climate

The dominant scientific theory is that burning carbon fuels, and the resultant increase in the carbon dioxide (CO_2) percentage (approximately 40% over the last 50 years) in the atmosphere is causing unprecedentedly high temperatures, which will continue substantially unabated. This theory is accepted by many scientists, much of the information media, and in public education at all levels, as irrefutable. The given cultural *solution* is that immediate countervailing action regarding CO_2 production is required due to the critical and irreversible nature of the consequences. But this assessment can only be as valid, or as effective, as the quality of the underlying science. The evidence, combined with a grasp of scrupulous science, makes it is relatively uncomplicated to evaluate whether bias is involved. As before, the following focuses on high probably knowledge to comprehend the big picture about the climate.

1] All features of the physics, the chemistry, and the biology that naturally affect the climate must be understood and accurately quantified, before it will be possible to truly grasp the effects of human activities on the climate. The science is noticeably incomplete and insufficiently precise for this purpose. 2] The average global air temperature, recorded at arbitrary and non-uniformly distributed points, with some affected by heat-island effects, is *never* an appropriate technique for scientists to determine the total heat in any system. Heat must be calculated by the total (or at the least the atmospheric) global *heat content* to take account of component materials' mass, specific and latent heats, and other factors. 3] Satellite radiation measurements provide far greater precision and accuracy as they encompass extensively more relevant heat *energy* in the atmosphere than point ground level readings. Satellite temperature inferences use similar technology to that used by astronomy and astrophysics; and have been essentially corroborated by direct measurements from balloons. Over their 40 year use the results show meaningfully less variations in temperature than ground thermometer data. 4] CO_2 represents 4% of greenhouse gases in the atmosphere, and 4% of that figure is caused by human activity. Consequently, no more than 0.16% of all greenhouse gasses currently results from the burning of carbon fuels. 5] The sun's total effect on climate is not considered or generally acknowledged by many scientists as the total solar irradiance variation (TSI) is small, but not zero (approximately 0.10% - 0.15%). This and other effects resulting from sun cycles (including cloud cover variations) are rarely represented in climate models. 6] Publicly available computer models designed to predict global temperatures have been shown to be significanly wrong, in both theory and in practice, such that the current models are scientifically irrelevant. 7] The world's flora has been shown to possess a mix of abilities to benefit from higher levels of carbon dioxide to increase forestation, crop yields, and leaf growth. 8] While the prediction that atmospheric CO_2 would increase over time was correct, virtually every *negative* prediction about a warming climate over the last 50 years (positive predictions are rarely reported) have turned out to be incorrect or entirely speculative attempts to create emotional fear. Temperatures have increased from the 1970s, but studies show they are historically unexceptional. Credible reports show the total polar bear population is currently high, near-surface fossils in the Maldives indicate the islands have not shrunk, and credible reports show extreme weather events and the surface ocean temperature has not increased concurrently.

Science Education

When scientific questions touch on cultural ideas the topics tend to focus on descriptions of the *past* (e.g. evolution) and solutions for the *future* (e.g. energy management). This contrasts sharply with the original motivation for scientists which was to understand the workings of the world as it presently exists, with everything else being called philosophy. Also, the definition of appropriate scientific methods has become significanly less rigorous than previously. These shifts in scope and the prominent scientific method have permitted the cultural sciences to define the paradigms for understanding all aspects of the past, the present, and the future; and thereby permit the scientific claim of complete knowledge.

This paper emphasizes the logical imperfections within the cultural sciences, and the need for students to develop advanced critical thinking methods. These skills require topics to be explored from *every* conceivable perspective, irrespective of popularity.

The nature and scope of human biases and paradigms must be detected by students. They should ensure high probability knowledge (HPK) always takes precedence over speculative data and opinions. The impartiality of scientific reports and reviews, including the framing of the work, need to be evaluated. Similarly, the student's predispositions must be controlled by continual checks on whether their thinking is being influenced by personal biases and paradigms; and that their emotions are not being deliberately triggered to cause their thinking to become disordered.

Conclusion

Science based upon assumptions and inferences that contravene or ignore high probability knowledge can "prove" practically anything. Logically, this imposes a categorical responsibly on the cultural sciences to openly demonstrate that their work is carried out impartially.

This thesis has no intention to persuade students *what* to think as topics and evidence continually change and everybody has personal paradigms and knowledge. Its purpose is to establish the need to distinguish cultural science from other sciences, to describe advanced thinking skills, and to stimulate discussion; with the suggestion that, practically by definition, obvious or uncomplicated explanations for complex issues will essentially guarantee erroneous conclusions.

Geoffrey V Francis DIC MSc PEng
June 12, 2019
5,080 words, plus the abstract.

Appendix

The Author

Geoffrey V Francis is a retired professional engineer who specialized in research and development and forensic science. His post graduate studies at Imperial College, London included the development of computer based mathematical models for structural numerical analysis. He was an independent engineering and science consultant for over four decades and has given lectures at various academic venues including Harvard University. He sat on a number of technical standards' committees and has acted as a peer reviewer for technical papers and has also focused on R&D and legal cases involving product and material failures. He frequently collaborated with scientists and other specialty investigators.

For the last ten years the author has studied the topic of *Human Biases* independent of a university faculty of social sciences. This approach was used to steer clear of any of the biases and paradigms that may have intruded into a university culture. This meant the author's personal biases would need to be vigilantly managed. This was made feasible by experiences gained as a forensic expert where opposing specialists and lawyers relentlessly accentuate and criticize every potential bias, error, or omission in one's thinking and reports. Decades of this work instilled a systematic approach to the investigation of data with a minimum of bias.

Topics - Key Words

1: Biases; 2: Paradigms; 3: Skepticism; 4: Critical Thinking; 5: Logic;
6: High Probability Knowledge; 7: Complex Science; 8: Cultural Science.