

CRITICAL THINKING AND THE EVOLUTION OF UNIVERSAL SCIENTIFIC TECHNOLOGY

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Abstract

This piece discusses the role of human knowledge in the evolution of science and technology from a philosophical perspective. The study shall show that although philosophy began with myth, it however took its distance from it. Philosophy's disassociation from myth was done on an epistemological footing. Such began the problem of how humans acquire trustworthy knowledge of phenomena in an environment. This has consequently remained a perennial epistemological issue. This work shall refer to such problem as the 'human epistemological conditions for selfpreservation'. It is a notion derived from the activities of science as a product of the human enterprise called 'knowledge' which is paramount to how we cognize the world. Scientific cognition therefore, is a derivative of a critical attitude towards all aspects of human realities. Such cognition is sharpened by philosophical skepticism; which is the attitude of never taking anything for granted. A salient question therefore, is how far and well can the philosophical skepticism be sustained in a futuristic world? This library-based qualitative study is expository, analytic, synthetic and critical. The research is done within the theoretical framework of John Dewey's idea of 'reflective thinking', a precursor to a scientific attitude of mind. The study is significant because it shows that critical philosophical thinking is a *sine qua non* for human advancement. It is the wake-up call for a critical attitude towards the quest for knowledge which can improve our natural tendency for self-preservation and the advancement of humanity.

Keywords: Critical thinking, Epistemology, Knowledge, science, technology, Universal

Introduction

Philosophy (from the Greek *philein*, 'love' and *sophia*, 'wisdom') means "love of wisdom". Essentially, philosophy constructs theories about man, his environment and the entire universe, thus proffering such theories as the basis for beliefs and actions with a view to the elimination of inconsistencies and errors. Philosophy carries out such task through its branches, two of which are known as epistemology and logic. Epistemology is that branch of philosophy which studies the nature, the origin, the foundation, the method, the validity, the extent and the limits of human knowledge (Omogbe, 1990:8). According to M. Shamshiri (2016:1), epistemology raises certain questions with regard to its object of study including: Is knowledge possible? What is knowledge made of? How is knowledge different from justified belief? What is the criterion for belief justification? Logic on the other hand, is a branch of philosophy concerned with critical thinking directed at distinguishing good or correct arguments from bad or incorrect arguments or reasoning (Unah, 1996:2). Interestingly, both epistemology and logic are critical to the growth of science. They are both fundamental to the skeptical crisis that inspired what is known as the "the quest for certainty" in modern

philosophy. This was evident in the rising influence of science and mathematics on philosophy; thereby leading to the great but rival coordinate epistemological traditions, namely, rationalism and empiricism (Okoro, 2008:5). Proponents of the former hinged their faith in the mathematical method, while the adherents of the latter insist on the empirical method on which modern science is built on. Science has been called “trained and organized common sense”.

Interestingly, its distinctive characteristic is its critical and accurate observation and description of things and events. The term science comes from the Latin word *Scire* to know (Hohenberg, 2010). Today the word science is used in a narrower sense to designate a quantitative and objective knowledge of nature. Science, in its applied, practical, utilitarian and durable manifestation is known as technology; which itself involves the purposeful application of knowledge, experience, and resources to create processes and products that meet human needs. Science and technology are now like Siamese twins. The use of the words “universal science and technology” here is tied to the issue of the universality of science which can also be put in the form of a question: Is science universal? Only recently has this question been given any serious consideration at all. In the tradition of science as practiced in the West for the past 300 years, the answer has been, “Of course science is universal” (Christophoron, 2009:5). Nevertheless, two prominent groups have emerged in response to the question. The two groups are the universalists and multiculturalists; sometimes rendered as the traditionalists and the relativists. These two can also be considered as the internalist and externalist respectively (Our concern here is with the former).

A central assumption of the universalist or internalist (which is an older theory of scientific knowledge) is that the success of modern science is inspired by its internal feature which is the experimental method or scientific method more generally (Hohenberg, 2010:10). It also involves scientific standards for maximizing objectivity and rationality, the use of mathematics to express nature's law, the distinction of primary and secondary qualities in nature. Advocates of scientific universality also maintain that science is singular; there is one and only one science, and its components are harmoniously integrated by the internal features identified above (Christophoron, 2009). Universalists prize not any old knowledge of the natural world, but knowledge which is (a) characterized in the form of theories that are (b) testable, (c) genuinely predictive (especially of novelty), (d) revealing of underlying unobservable entities and the relations and mechanisms (and/or stochastic regularities) in which they are involved, and (e) genuinely and deeply explanatory. The production of such knowledge is the ultimate aim of scientific inquiry.

Now, in a similar tone to philosophy, science constructs theories about man, his environment, and the entire universe. It proffers such theories as the basis for beliefs and actions. Furthermore, science brings critical methods to bear on these theories in experiment. Philosophy and science therefore appear to have a closely knit relationship; in their origins philosophy and science were indistinguishable (Nwalozi et al 2014:56). The greatest philosophers in human history including Thales, Pythagoras, Socrates, Plato, Aristotle among others, constructed and tested several scientific theories. This explains why in his attempt to

distinctly separate philosophy from science, C.M. Broad according to Nwalozie et al, (Ibid,60) wrote that science aims at explaining and is therefore speculative philosophy, while philosophy aims at understanding and is therefore critical. In this study, we examine how philosophy as the epitome of critical thinking (the words critical thinking and critical attitude shall be used interchangeably) contributes to the evolution of universal scientific technology since the earliest times to the present. The paper also digresses a little by showing how Immanuel Kant's metaphysical and epistemological analysis of human knowledge guarantees the noble place of critical thinking to the future of universal science and technology.

Meaning, Scope, Nature and relevance of Critical thinking

Historically, the use of the term 'critical thinking' to describe an educational goal can be traced back to John Dewey, an American philosopher, who preferred to call it 'reflective thinking'. He defined it as "active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends (Dewey 1910:6)". Dewey identified a habit of such consideration with a scientific attitude of mind. This indicates that the philosophical and scientific root of the term 'critical thinking' eventually gave rise to its meaning, scope, nature and relevance. This day, many philosophers in the course of giving working definition to the concept of critical thinking has defined it variously as "doubtful and argumentative inquisitiveness that aims at establishing evidentially valid conclusion" (Umotong 16), in the same vein Egbeka Aja as cited in Ozumba defined it as "reasoning validly and arguing soundly" (Ozumba 10). Let's also mention that, before Dewey, there was a prominent German philosopher called Immanuel Kant. The keystone of Kant's philosophy, sometimes called critical philosophy, is contained in his *Critique of Pure Reason* (1781) in which he examines the basis of human knowledge and created an individual epistemology. Kant informs of the ideas of time and space, which he called "pure forms of intuition" as well as that the mind necessarily contains a number of fundamental concepts which he called "categories" (Kant, 1970:5). Therefore, for Kant the forms of intuition and the categories belong to the mind and they are applied by the mind to our perceptions in order to gain knowledge. In the context of this work, such knowledge is universal scientific and technological knowledge.

Significantly, there are several types of thinking such as: creative thinking, design thinking, innovative thinking, positive thinking, and of course critical thinking. As we aware in this study, our concern is on critical thinking, of which there is a mountainous body of literature defining it and its elements. One of the most comprehensive, concise operating definitions is according to K. Petress (2004) provided by M. Scriven and R. Paul:

Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action.

Paul and Scriven go on to suggest that critical thinking "is incorporated in a family of interwoven modes of thinking, among them: scientific thinking, mathematical thinking, historical thinking, anthropological thinking, economic thinking, moral thinking, and philosophical thinking" (Ibid). A more

recent definition of critical thinking is provided by J. Heard et al (2020:2) with the assertion that;

To think critically is to analyse and evaluate information, reasoning and situations, according to appropriate standards, for the purpose of constructing sound and insightful new knowledge, understandings, hypotheses and beliefs. Critical thinking encompasses the subject's ability to process and synthesize information in such a way that it enables them to apply it judiciously to tasks for informed decision-making and effective problem-solving.

Critical Thinking has also been defined as 'the analytical thinking which underlies all rational discourse and enquiry. It is characterised by a meticulous and rigorous approach' (Paul and Elder, 1997:23). These definitions strongly relate critical thinking with rationality. Little wonder G. E. Azenabor (2004:56) intimates us that one of the senses of the word "critical" is for something to be rational. The question then is, what is rationality? How do we determine something to be rational? It is often taken for granted that for anything to be rational, it must be agreeable to reason, that is amenable to the rules of logical reasoning. R.B. Edwards according to Azenabor (2004:57) identifies the meaning of the word "rationality", especially when used by philosophers. He writes:

A man is rational when his inferences are logically correct, when he simply follows that rules of correct inference in arriving at conclusions; and his conclusions are rational if they have been reached through such inference procedure. "Rational" in this sense is interchangeable with logical.

The point is that, all rational discourse and enquiry involve the activity and application of critical thinking, and both formal and informal rational discourse and enquiry rely upon analytical and reasoned thought (Petress, 2004:134). Many of the processes of critical thinking rest upon the ability to be analytical; to be able to dissect arguments and information. Good critical thinking is exemplified when the thinking is rigorous and meticulous, that is to say it is not passive, automatic, spontaneous or reactive in manner, but is active, careful and thorough (Gyenes, 2015:4).

The reference to critical thinking as an academic discipline acknowledges that it is a skill which can be explicitly and purposefully taught and learnt. According to K. Petress (2004:29), the value of the discipline is that it can be applied in all contexts in which reasoning occurs or should occur. Besides, open-mindedness is also important, since being able to set aside one's views is a pre-requisite for a fair examination of others' arguments. Furthermore, open-mindedness allows a person to acknowledge that their own views may be unsupported or even wrong. Importantly too, the definitions indicates that critical thinking is a set of skills which one applies not only to other people's reasoning, but also to one's own. Thus, being

rational requires analysis, evaluation and elucidation of one's own thinking, with the aim of greater accuracy in one's own reasoning.

Against the foregoing background, it is clear to see that critical thinking from its scope and nature is reflective, it involves standards, it is authentic, as well as it is reasonable.

i. Critical Thinking Is Reflective

Critical thinking is different from just thinking. It is meta-cognitive, as it involves thinking about your thinking (Dwyer, 2023:56). Critical thinking starts once I for instance, reflect on my thinking: Why do I have these views about race? Since my views are really conclusions I have drawn, what evidence are they based on? How do other people look at race differently? What are their views based on? How can I tell which are more accurate, their views or mine?

ii. Critical Thinking Involves Standards

Critical thinking involves having my thinking measure up to criteria. I can think about something accurately or inaccurately. I can use evidence that is relevant to an issue or irrelevant, or somewhere in between. For my thinking to be critical thinking, I have to make judgments that meet criteria of reasonableness.

iii. Critical Thinking is Authentic

Critical thinking, fundamentally, is thinking about real problems. Although one can reason out puzzles and brain-teasers, the essence of critical thinking comes into play only when a person address real problems and questions rather than artificial ones. Critical thinking is far more about what one actually believes or does. It is about good judgment.

iv. Critical Thinking involves being Reasonable

Basically, one has to be aware that there are no rules so foolproof that they guarantee one's reasoning will be successful. There are guidelines, even "rules" sometimes, but these always need to be followed thoughtfully, not by rote. One needs to apply them with sensitivity to context, goals, practical limitations, in fact, a whole host of realities. For thinking to be critical thinking, it must be reasonable thinking (Gyenes, 2015:199).

Some impediments to critical thinking include:

Forming a Picture of the World on the Basis of the news or news presentations is likely to be seriously distorted thereby affecting our chances for critical thinking.

Forming a Picture of the World on the Basis of Movies, TV, Advertising is of a greater distortion than even news presentation.

All-or-Nothing Thinking (Black-and-White Thinking),
Us-Versus-Them Thinking, Stereotyping: Thinking in terms of concepts like these is a way of simplifying our world. In fact, each of them vastly oversimplifies the complexity of reality, and each serves as an excuse for not thinking things through (Fisher and Scriven 1997:9).

Although, all fears may not automatically be an impediment to critical thinking, some fears do tend to become obstacles. Among such fears include: fear of making mistakes; fear of trying something new, of sticking your neck out; and fear of looking foolish to mention a few (Fisher and Scriven 1997).

Some prevalent educational practices discourage critical thinking, and internalizing them as a model of what education should be can seriously affect your critical thinking. These practices are based on assumptions such as: the student's role is to be a passive recipient of knowledge, as well as, the student's role is to memorize and regurgitate information

H. Siegel, (1980) identifies a fundamental relevance of critical thinking to its versatility. It is valuable at all levels of our thinking; or can be applied in all contexts in which reasoning occurs or should occur. Three contexts are worth mentioning here. At the level of practical decision making it helps when we are simply trying to deal with ordinary tasks: how to write an academic work more efficiently for example. At the level of meaningfulness, critical thinking opens up other viable courses of action that leave people far more fulfilled, paths that otherwise might never occur to them. In fact, toward all the things that makes life meaningful for us as humans (Ibid). It is also relevant at the level of concepts. Since we think in terms of concepts, which inevitably shape our life to a considerable degree we can reach a deep level of critical thinking by examining our concepts critically, becoming more aware of the way individual concepts help us or hurt us, limit us or free us.

Furthermore, critical thinking in the view of R. Paul and L. Elder (1999:8) also improves character traits. In this case, two traits readily come to mind, they include intellectual courage and confidence in reason. Intellectual courage involves the willingness to face up to challenges to one's settled beliefs as well as habitual ways of thinking about things. Critical thinking will definitely challenge long-established ways of thinking one may have. It can make us to be alert to an improvement in our intellectual courage. On the other hand, confidence in reason describes the willingness to try to figure things out, to rely on thinking one's way through things, to the best of one's ability, rather than on all the other influences that shape our thinking without us knowing it (Fisher and Scriven, 1997:7).

Pertinently, critical thinking goes beyond problem solving, as it is in the realm of asking questions (Paul and Elder, 1999:17). Just as in philosophy, questions are a fundamental part of critical thinking. In fact, one of the most difficult skills in critical thinking is learning to notice that there is a question one should be asking, a problem one should be solving. In problem solving, on the other hand, someone presents the problem, while it is another fellow's job to solve it. Critical thinking is different because it begins with posing the problem in the first place. It is in our daily attempts in solving problems critically that knowledge evolves and human advancement occurs.

The Human Epistemological Condition and Self-Preservation

The human epistemological condition and self-preservation as used here refer to the condition which obtains as a result of the human attempt to preserve life through knowledge sought and

acquired in relation to the environment. Etymologically, the word epistemology derives from the Greek words *episteme* (knowledge) and *logos* (theory). It is a branch of philosophy which may also be referred to as 'Gnosiology' (Omogbe, 1990:3). As a branch of philosophy, it is concerned with the study of knowledge. The knowledge which is the focus of the study of epistemology is objective and scientific knowledge (Ogbinaka, 2006:56). Knowledge in this sense, is stable than mere true belief, because knowledge, unlike mere true belief, could not easily be mistaken (Pritchard, 2014:26). Although opinion, myth, and belief may generally be called knowledge, they do not however constitute objective and scientific knowledge that epistemology seeks. Hence, most epistemologists commence their study by first of all distinguishing knowledge from belief or opinion. E. A. Ruch (1981:5) puts it this way:

Man is conscious of objects and of himself, he think a variety of thoughts: he imagines a multiplicity of images, he makes judgment and draws conclusions from premises, he claims to know certain truths, to have insight into certain states of affairs, to create theories and sciences about certain areas of experiences.

Consequently, a critical starting point of epistemology is "commonsense" and some forms of "doubt". It is common sense in so far as we do hold uncritical opinions about things around us. These are generally accepted notions that have been lacking in our daily conducts of human affairs, and which we have not had cause to do away with perhaps on the ground of utility. Examples can be found among some of the knowledge and practices that thrive in our indigenous communities. For instance, among the Yoruba *Lala to roke, ile lo n bo* translated to mean 'whatever goes up must come down' is a commonsense knowledge. Interestingly, a little skepticism of such generally accepted notions can help refine them in consonance with the vagaries of modern realities.

The skeptical attitude ushered in the study of epistemology as a prominent branch of philosophy. This shows why epistemology since the modern period started with the question of, "how we come to know all that we claim to know"?. On this note, K. Ogbinaka (2006:23) asserts that:

Epistemology is not an attempt to discover certainty, truth or an attempt to validate knowledge *exnihilo*. It attempts to do these on some form of "being" which confronts the knower. It is the quest of the knower to provide better grounds (called justification) for already held beliefs and opinions.

Also apt here is J. Cunningham and J. Fitzgerald (1996:3) understanding of epistemology as "the study of what can be counted as knowledge, where knowledge is located, and how knowledge increases". Consequently, the perennial questions include: whose responsibility is it to count something as knowledge, to know when and where to locate something as knowledge, and finally, to know when such thing counted as knowledge and located as knowledge has increased?

Generally, humankind has been regarded as the most intelligent of animals. He can think, judge right from wrong, appreciate beauty and goodness, as well as abhor ugliness and evil. Man (of course, in the sense of men and women) has a will to choose. Unlike the rest of the animals, humankind can adjust to most, if not all, environments. Man possesses the ability to develop its own potentialities from contact with others and can utilize the resources of his environment (living and non-living) to enhance and sustain life for survival. Thus, majority of all that humankind knows is learnt. Mankind uses the wisdom of past experience to enable and promote life in the present and plan for the future.

Interestingly, humankind has similar physical nature and attributes as other animals, but in addition, is endowed with a spiritual nature which places her in the highest pedestal amongst the rest of the animal kingdom. Besides, because humankind possesses both physical and spiritual attitudes, it has the potential to seek and abstract such qualities as goodness, beauty and truth. Essentially, man's efforts to cognize his potentialities as well as the environment is an epistemological condition whose ultimate goal is not only about the preservation of human life but also the advancement of knowledge. As B. Sweetman (2005:56) puts it: "perhaps we never shall meet a human group whose behavior is un-adulteratedly magical or scientific... Magic, religion, and science are born out of man's necessity to know the world in which he lives". Scientific and technological advances since the early times epitomize such epistemological condition. Following the foregoing, humankind is epistemologically responsible for what can be counted as knowledge, where knowledge can be located, and how it increases. Scientific and technological knowledge and advances have often towed such epistemological path in the evolution of scientific technology.

That science and technology have become indispensable to human existence is not in doubt. Virtually every aspect of human life has been profoundly influenced by it. Pure science is the theoretical enquiry by which new ideas are invented and laws of nature discovered. Technology refers to the application of known scientific ideas and laws to the design of technological gadgets. Technology, therefore, is the application of scientific knowledge to human ends (Makinde, 2011:23). It is the means by which humans have conquered and dominated nature and their environment. By means of technology, human beings now have dominion over the sky, the earth and everything it contains, including the oceans. Even the epistemological anarchist, Paul Feyerabend, concedes that science has made marvelous contributions to our understanding of the world and that this understanding has led to even more marvelous practical achievements (Feyerabend, 1978:45).

Furthermore, science is an endless voyage of learning, a continual adventure into the unknown, a quest to know and understand the world in which we live. Science tells us what we can know even if what we can learn is little compared to the whole of reality. Its aim is the discovery of the laws that govern natural phenomena. Hence, M. Tomszak (2016:4) perceives it as the "systematic knowledge of nature through repeatable observation and experimentation". Science developed from the observation of regularity in the natural world. For instance, the return of spring after winter, the setting of the sun at a day's end, the falling of the ebb tide after high water, as well as regularity suggests that nature is not all chaos but follows rules. Defined in this way, science has been a human activity well before the development of the first civilizations. In actual sense, science started with the early man who made use of crude

reasoning to solve his environmental challenges. For more than ten thousand years, humanity had advanced in his bid to critically subdue his environment through reasoning and its applications.

A brief discussion about what motivated people to scientific study in the earliest human societies is apropos here. Such early evidence of scientific activity does not mean that the ancient Africans and Egyptian, Chinese and Indian societies employed scientists after all. As R. Horton (1997) maintain, "the very elementary purposes of survival human thinking in all cultures, is geared towards explanation, prediction, and control of all sensed phenomena". Accordingly, the essential feature of science includes an inquiry into the structures of the natural world with the explicit goal of certifiable explanation. Thus, a hallmark of scientific investigations is careful, detailed and rigorous analysis expressed in objective language and strict measurement. In this regard, mathematics is of special importance to science and the scientist.

The term "scientist" as a description of a profession was first used in the 19th century. In early indigenous societies, scientific study was undertaken by priests (*babalawo* and *onisehun* among the Yoruba and *dibia's* for the Igbos of Nigeria in West Africa) and monks, and scientific knowledge was taught in shrines, temples and monasteries. As civilizations developed, the link between science and religion weakened and science became the domain of philosophy. However, a clear distinction between science and religion did not develop until well into the 18th century.

Significantly, religion, like science, attempts to establish a system of knowledge about nature. Most religions are based on the belief that gods act in an orderly fashion and make sure that nature follows rules. The human mind is opposed to chaos; it can only make sense of an ordered world and finds order to meet its needs, even where order may not exist. Nature does contain a certain amount of chaos: Comets come and go; some appear regularly, others just pass through and are never seen again. The medieval belief that the appearance of a comet causes disorder on earth was a misguided attempt to find order in a chaotic process. There is, however, one central difference between the ways in which science and religion find order in nature. Science is a system of knowledge based on repeatable observation and experiment, while religion is a system of knowledge based on faith. Early societies had only limited means of experimentation, and their endeavour to discover the laws of nature had to rely on a range of unverifiable assumptions. As knowledge progressed, the need for unverifiable assumptions decreased progressively, and eventually science and religion separated. However, religious belief can still stimulate scientific discovery today.

Albert [Einstein's succinct words: "God does not play dice" expresses the belief in an](#)

impersonal God who loves order, a belief that influenced his approach to scientific study and led to new scientific insight. People in early human societies had to spend much of their time procuring food and shelter and could not afford to put much effort into non-essential activities. If science was practiced in the earliest societies it must have been for a purpose; in other words, science was undertaken for practical applications. Sometimes

the practical applications resulted in new technological developments. The word *technology* has changed its meaning several times since it came into scholarly use during the 17th century. In the most general terms, it can be defined as the application of knowledge about nature to practical aims of human endeavour. If this definition is accepted it follows that rudimentary technological development occurred through trial and error which is basic in scientific investigation. Stone-age humans realized that flintstone produces better cutting-tools than sandstone. They made that discovery and used their new knowledge well before someone found the scientific explanation for the phenomenon. Long periods of human history were characterized by the mastering of technologies such as the smelting of copper, bronze or iron, without much knowledge of the underlying scientific principles. In some societies this lack of scientific understanding gave technology mystical qualities and led to misguided activities such as medieval [alchemy \(unscientific attempts to convert lead or other metals into silver or gold\) or the quest for immortality through chemical concoctions in ancient China and in some parts of Africa](#). Today the situation is very different. Most new technology is the result of scientific research that preceded it. It is also now generally accepted that science and technology are closely linked and that science provides the theoretical underpinning for its technological applications. The symbol of this symbiosis is probably [Thomas A. Edison, the first engineer to establish a factory for inventions just before the 20th century](#).

Consequently, it is obvious that technology and science have to be seen as closely related, since both require systematic thinking and experimentation. They began as parallel developments, initially more or less independent of each other, but grew closer as the centuries progressed and became inseparable eventually. The key word here is “systematic thinking”. Interestingly, it is philosophy as an academic discipline that provided the systematic thinking required for the advancement and achievement in modern science and technology. The philosophical activities of some major philosophers such as Thales, Heraclitus, Plato and Aristotle (to mention a few) since the era of ancient Greek philosophy is an attestation.

In sum, in the course of the advancement of culture and civilization, scientific and technological knowledge has assisted humanity to understand nature as well as exploit the mineral resources located under the earth's surface (minerals such as zinc, iron oxide, coal, uranium etc). Following this, different types of extractive industries have elevated, among other things, the agricultural and economic status of humanity. All these were triggered by the human epistemological condition, and given further systematic boost by the resulting philosophical activities which emerged later. This point is further buttressed by Keita, in his explanation of the past and ongoing epistemological conflict between metaphysics and empiricism:

The history of human thought may be described as attempts to understand the sensory world in terms of the structure of phenomena as they exist in time. The sensory world presents itself to humans in myriad forms: forms that appear to be protean, forms that seem to be constant and static, and forms that

interact with the human organism in ways that demand understanding, that is, explanation. Human pragmatism effected along the lines of trial and error, has historically been the source of technology which in turn reflects particular levels of explanation and prediction. It was this essentially empiricist approach to sensory experiences that formed the basis for what later developed into scientific analysis (1999:10).

Scientific analysis actually began with the activities of the earliest philosophers. Such activities are what Karl Popper (1959) has referred to as an “un-ended quest”. *A sine qua non* for such un-ended quest is the critical attitude which best describes the intellectual enterprise called philosophy. Stated differently, the philosophic activity of critical thinking led to further techno-scientific advances in recent times. Therefore, the role of philosophers as agents of change in the advancement of knowledge cannot be underestimated.

Philosophy as Critical thinking and the advancement of science

Furthermore, philosophy as the foundation of the sciences is drawn from the fact that it (philosophy) offer's a rational explanation of nature. Rather than rely on the idea of gods, spirits and supernatural notions to explain nature, philosophers rely on human reason and the facts of experience. Although it is not to say that religious and supernatural explanations can be completely abandoned, they are however inadequate as explanations of empirical state of things in the universe. Thus, the pure sciences (physics, chemistry, and biology) especially as practiced in modern times are by-products of the rationalistic methods of explaining nature.

Advancements in science are achieved by the critical evaluation and possible refutation of theories. In the process, new inventions and discoveries could result. By so doing, the errors and timid assumptions originally made in the acceptance of the theory will be noted and repudiated (Ndubuisi, 2001:89). Stated differently, theories in science are made to be in stiff competition with each other. The adoption of a critical attitude to them ensures that it is only the fittest that survives. There is no chance for the emergence of fragile and weak-founded theories by the application of a critical method. Karl Popper (1959) (a prominent modern philosopher of science) believes that there is much sense and rationality in this procedure. In his view, among other factors, critical argument is germane to the success of science. The rational critical attitude is therefore the hallmark of science. If there was no critical attitude, it is highly doubtful if we can have science as we have it today. In this vein, Popper states that, “Science is differentiated from the older myths not by being something distinct from a myth, but by being accompanied by a second order tradition- that of critically discussing the myth” What obtained initially was the first order tradition, when there was just a story documented or orally transmitted. Eventually, aside the story being transmitted, there is also a provision for rational discussion, for critical reflection and its consequent: acceptance, modification or complete rejection. The second order tradition (critical

attitude) is fundamentally one of the greatest assets of science. The rationalists believe that “science is essentially critical; that it consists of bold conjectures, controlled by criticism, and that it may, therefore, be described as revolutionary” (Popper, 1959:34)

In perspective, science is seen as myth-making in comparison with religion. There is a difference, however, between the myths of science and those of religion. This difference centres on the critical attitude of the former and the dogmatic attitude of the latter. When a scientific myth is presented, there is an open-mindedness about it. Any interested person can use it to solve a given problem. After attempts to do this fails or succeeds, it could then be said that this myth is suitable or not for the handling of this kind of problem. This finding will form the basis for its rejection or acceptance. By so doing, the growth of scientific knowledge will be enhanced.

There are two ways through which one may explain the growth of science. First is that which perceives science in terms of accumulation of knowledge, like a growing library, or a museum where knowledge could be assessed by the extent of the accumulation of books. The second one explains growth by the intensity of criticism. This method of growth is according to Ndubuisi (2001:102) following Popper, more revolutionary than a simple accumulation of knowledge. This latter method involves the destruction, changes and alteration of everything, even its most vital instrument and the language in which our myths and theories are formulated. The first method Popper (1959) sees as less important, and contrary to popular opinion, he believes that “the accumulation of knowledge in science is very less when compared with the revolutionary changes of scientific theories”. If the growth of science is attained by the accumulation of knowledge, it makes no difference if scientific tradition is lost, for at any point in time, a fresh accumulation could start. On the other hand, if the advancement of science is along the tradition of changing its traditional myths, there is thus the need for something with which to start. In the absence of anything to be changed or altered, humanity will remain static. But because science does not permit this, it possesses two major essential beginnings, namely, the emergence of myths and a subsequent new tradition of changing the same myths critically. The kind of tradition that needs to be preserved in science is, for instance, the use of descriptive language. Language, Popper argues, grows together with the growth of myth, and every language preserves this tradition, for if they are destroyed it will be impossible to start accumulating any knowledge in the first instance. A pertinent question in the light of the foregoing is, what is the role of critical thinking to the future advancement of universal science and technology?.

The noble place of Critical thinking to the future of universal science and technology The place of critical thinking to the future of universal science and technology can be examined through the metaphysical and epistemological analysis of the human mind by an 18th century philosopher called Immanuel Kant. His analysis is also referred to as 'critical philosophy'. The critical philosophy of Kant, that gave later gave direction to his conception of science, was a direct reaction to the empiricism of David Hume. As he {Kant} following N. K. Smith put it:

I openly confess that the suggestion of David Hume was the very thing which many years ago first interrupted my dogmatic slumber and gave my investigations in the field of speculative philosophy quite a new direction (Smith, 1963:46).

Kant retained Hume's location of the source of knowledge in sense-experience, but he rejected Hume's agnostic-skepticism. Kant's philosophy, furthermore, is a critical philosophy, because it is an investigation into the nature, as in the phenomenology of both inorganic and organic nature; the functions and the limits of human reason as a faculty for acquiring knowledge.

Moreover, one may peruse Kant's position through the eyes of some modern philosophers. There is the belief amongst many philosophers today that the human mind is a computer like system that can be duplicated in a man-made machine (Oluwole, 1982:8). That this identification may be false in details does not, according to S.B. Oluwole, raise any serious problem. What sounds much more difficult to uphold is that it is false in principle. From all intents and purpose the mind appears to be a logical system. This means the working of the mind is lawful, a system of calculus. Whether or not its laws are physical and hence can be duplicated by man is an open question. What seems not open to question is whether or not it is lawful at all; whatever peculiarities the law might have (physical or even non-physical ones).

Significantly, Kant left an indelible mark on the sands of time in the field of philosophy; as a reconciler of rationalism and empiricism (two rival epistemological schools of thought). In natural science no less than in mathematics, Kant held that \, synthetic *a priori* judgments provide the necessary foundations for human knowledge. The most general laws of nature, like the truths of mathematics, cannot be justified by experience, yet must apply to it universally. In this case, the negative portion of Hume's analysis, his demonstration that matters of fact rest upon an unjustifiable belief that there is a necessary connection between causes and effects was entirely correct. But of course, Kant's more constructive approach is to offer a transcendental argument from the fact that we do have knowledge of the natural world to the truth of synthetic *a priori* propositions about the structure of our experience of it. On the other hand, applying the concepts of space and time as forms of sensible intuition is necessary for any perception. But the possibility of scientific knowledge requires that our experience of the world be not only perceivable but thinkable as well. Besides, Kant held that the general intelligibility of experience entails the satisfaction of, what Smith (Ibid, 45) has identified as two further conditions.

According to Smith, first, it must be possible in principle to arrange and organize the chaos of our many individual sensory images by tracing the connections that hold among them. This Kant called the "synthetic unity of the sensory manifold" (Kant 1970:88). Second, it must be possible in principle for a single subject to perform this organization by discovering the connections among

perceived images. This is satisfied by what Kant called the “transcendental unity of apperception” (Ibid, 93). Thus, experiential knowledge is thinkable only if there is some regularity in what is known and there is some knower in whom that regularity can be represented. Since we do actually have knowledge of the world as we experience it, Kant held, both of these conditions must in fact obtain.

Kant held that invention or creativity and discoveries come about as a result of the functioning of the faculties of consciousness. By the process (i.e method) of “transcendental (time) deduction” the first thing we are aware of or that confront us (about reality) is a hunch or an idea about an existing problem. It is this hunch, or ideas, or awareness of a problem that first ignites our curiosity and sets us to work, that is, the embarkation upon that rigorous activity known as research which is the hallmark of any serious attempt at surmounting a problem.

Significantly, the process of transcendental (time) deduction” by which we develop a hunch about an existing problem is reason's own functioning. It is reason that legislates the idea or spectacle with which we appreciate a problem at the first instance. However, this “transcendental (time) deduction” according to J. Unah (1997:67) “would be impossible without the affinity or rapport among all the faculties of the mind”. For instance, by the quality of a priority thought or the understanding make objects to lie in wait for intuition which ignites them as sensibility for onward unity or synthesis by the imagination which function is the production of “images”. The images produced by the imagination then attain final purification as “concepts” in the faculty of thought through the process of schematism known as subsumption. The pure concepts produced by the understanding (which intrinsic feature is universality) are then used as guiding principles to orient or teleguide our research or activity in progress (which was first ignited by our idea or awareness of a problem). It is this process of persistent research or rigor that results in discovery, or creativity or invention.

The acute awareness of the foregoing metaphysical and epistemological analysis as captured by Kant, aptly explains the Western scientific dominance over the rest of the world. Importantly too, it underpins the continual relevance of critical thinking to the future advancement of universal science and technology.

Conclusion

This work has discussed the role of human knowledge in the evolution of science and technology from a philosophical perspective. We showed that the problem of how humans acquire trustworthy knowledge of phenomena in an environment will often be a perennial epistemological issue {perennial because of the dynamic and uncertain nature of knowledge and human reality}. Such condition is here referred to as 'the human epistemological condition and self-preservation', which however has been taken to its apogee by universal scientific and technology. The attempt by humans to seek the good life is often fraught with challenges and often partial. Consequently, philosophy as critical thinking becomes relevant because it encourages the attitude of not taking any

belief or assumption for granted. In the words of O. Oladipo (2008: 8) “it allows us to examine the grounds for the validation of a belief or opinion that is presented as being true or plausible”. As critical thinking the function of philosophy is to scrutinize the ideas and values we live by, with a view to determining the extent to which they are compatible and compliant with the vagaries of existence. Interestingly, the critical attitude provided the relevant philosophical principles essential to science, such as uniformity, simplicity, comprehensibility, lawfulness to mention a few. It also provides a deeper and lucid understanding of reality; a reality that is multi-faceted and not neatly compartmentalized. Such understanding that has worked for the success of universal science and technology in the past, and even the present, clearly has a continual noble role to play in the future as well.

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