New technologies, the Infoworld, and the need for actionable knowledge

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Abstract: This article is about knowledge with power or else actionable knowledge. This kind of ability knowledge is often neglected in mainstream epistemology but its importance in today's information society should not be underestimated. The central element here is the Infoworld, a ubiquitous world projected via the Internet. It is argued that information acquired via this world can be transformed into knowledge by means of logical inference. Knowledge acquisition is seen here as a continuous-time feedback process with its stability depending upon reliable information.

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New Technologies

Life is becoming increasingly digital, and this often results in complexity. Let us for a moment take a look around our homes and workplaces, here in the industrial world, and try to count the number of machines, devices and gadgets. Many of them are already connected to the Internet, while others not so obvious wait for the opportunity to join.

The trend towards an all-round connectivity is evident. Portable computers and tablets are widespread and the same is true of smart TVs. Mobile phones, digital cameras, light bulbs, and home appliances all have built-in intelligence. E-book readers have WiFi, WiMax or 4G connections, and cars are fitted with navigation systems. The so-called "smart life" is already here. The driving forces behind the pace towards a "ubiquity of technology" can be identified as follows:

i. *Nanotechnology.* Control of physical matter on atomic and molecular scale. Structures are about the size 100 nanometres. Electronic elements such as gates are then constructed according to that size.

ii. *Autonomous Systems.* Electronic systems with the ability to search and perceive their environment, translate perceptions into actions, and then execute these actions without human supervision. Examples are intelligent robots for the monitoring of production, e.g. in the assembly lines of cars. Other examples are found in the military domain under "surveillance".

iii. *Cloud Computing Systems.* Large computing installations that enable on- demand access to computing resources across the Internet. Storage of data and information processing take place in a "cloud" located far away from the users' premises. Services are fully configurable according to users' needs. Because of the distributed nature of these systems, cloud users have the illusion of unlimited resources.

iv. *Internet of Things.* A technology utilizing the concept of machine-to-machine communication (M2M). It is a new paradigm in which end-to-end communication is accomplished without human intervention. Technically, IoT appears to users as a global network infrastructure with self-configuring capabilities and protocols. The so-called "things" are entities of either physical or virtual nature. They use the available infrastructure seamlessly via built-in intelligent interfaces.

v. *The Semantic Web.* An extension of the world-wide web that allows network computers to understand the demand of applications *a priori.* Semantic Web technologies help increase efficiency and provide enhanced services based on virtual operating systems.

These developments gradually alter our perception of the world. The first point to note comes under the heading of "digital convergence". This is the result of the successful merge of previously separate technologies, such as voice, text, audio, and video, all of which are converted into digital form and transmitted through global networks. A second point concerns the "ubiquity of technology" as noted. This is nowadays promoted via the engineering of the so-called ubiquitous digital networks, a grand vision that is expected to remove any remaining

barriers between fixed and mobile networks. Finally, a third point concerns the world-wide reforms presently taking place in both the electronics and telecommunications industries.

The forces of Information and Communication Technologies (ICTs) already influence modern life. Faced with the above, one might think of man as the "weak link" in a world of complexity; but such a thought is far from new. Let us consider this passage (Einstein, 1939): "Our time is rich in inventive minds, the inventions of which could facilitate our lives considerably. However, the production and distribution of commodities is entirely unorganized so that everybody must live in fear of being eliminated from the economic cycle." Unfortunately, the so-called digital divide, a gap with many facets (economic, social, cultural, etc.) is evident almost everywhere. Crossing the digital divide has proved to be a hard task even for countries with the best of plans (Mansell and Tremblay, 2013).

The Infoworld

Knowledge acquisition is a common subject in a number of diverse scientific fields including epistemology, artificial intelligence, and the cognitive sciences. In this work, we approach knowledge acquisition from a practical standpoint, focusing on a kind of ability knowledge known as *actionable* (Argyris, 1996). Actionable propositions are initiated by actors who use them to implement their intentions effectively: examples of such implementation are common in business and management. As Chris Argyris has written, "actionable knowledge is not only relevant to the world of practice; it is the knowledge that people use to create that world". Our view here takes into consideration the importance of actionable knowledge in a digital world. Since much of the information we receive today comes via the Internet, it seems reasonable to examine first the elements of information acquisition via the senses.

We begin with the following statement which is attributed to Democritus. (Author's rough translation from the original Greek text.) Democritus of Abdera once coined a dialogue between *Aestheses* and *Noesis.* The Aestheses say: "Poor Noesis, now that you have got from us all the information about the real world, are you now trying to deny our offer? If you emerge as a winner of this dispute, your victory will be your disaster. You will no longer have any information." Such a strong view of the power of the senses can somehow be moderated if we accept that sense and intuition can, and often do, work in cohort.

In the rest of this section we examine the structure the Infoworld and the users' access to it. In doing so, we shall first need to discuss some relevant aspects from the field of epistemology.

Epistemology is concerned with the origin and properties of knowledge. Our epistemological view considers randomly distributed groups, or clusters, of people who interact with the *Infoworld,* which is defined as a ubiquitous world of information provided by the convergence of new technologies. The Infoworld has many inter-related components, e.g. computers, networks with routers and servers; modems/codecs; cables of all kinds; fixed and mobile devices; communication protocols; routing/flow control mechanisms; and, of course, digitally-encoded information stored in large distributed databases.

The above sketch of the Infoworld is, in our view, compatible with the principles of epistemology. In the Infoworld, sense and intuition are assumed to work in harmony. Therefore, what the users of the Infoworld perceive is connected to what they already know, i.e. to their background knowledge. Information is assumed to be transferred via bit-streams the content of which is converted into perceptions. These perceptions can then be transformed into knowledge by means of logical inference. However, such knowledge often contains uncertainty. Hence, knowledge gained via the Infoworld should be the subject of inspection. Also, certain additional assumptions must be made in order to claim such "real-world" knowledge.

The problem of assumptions can be illustrated as follows (Klempner, 2007): "What we call our 'knowledge' rests on a vast network of assumptions; assumptions whose truth or falsity would be impossible to check or prove in their entirety. We might feel safer making the more modest claim that all we really know is what each of us has learned directly through our senses. Everything else we believe comes under the heading of the 'best explanation' of our sense experiences."

Let it be noted that the above network of assumptions has a clear similarity to the well-known series of *"if...then...else"* statements often expressed as logical conditions in algorithmic programming languages. Similar statements are also found in modern knowledge-based systems incorporating artificial intelligence. The existence of an Infoworld is taken for granted in this study. Such existence is in accordance with empirical evidence from the well-known discipline of information systems and networks. Thus, knowledge is, to a good degree, the result of our interaction with the Infoworld. A similar name for the Infoworld, namely Infosphere, was recently proposed (Floridi, 2014). In Chapter 3 of his book *"The Fourth Revolution"*, Floridi writes that the Infosphere is neither entirely virtual nor only physical; and that the Infosphere is a good reminder of how influential ICTs are becoming in shaping our identities.

In this article we focus only on the physical properties of the Infoworld as part of the natural world. This is because we are not certain about the meaning of such concepts as on-life, or social self, and their psychological consequences. However, we do accept Floridi's remarks about *interactability*, a notion closely related to our definition and function of the Infoworld. According to Floridi knowledge and information are both members of the same conceptual family. The difference is that knowledge contains a web of mutual relations, which are called interconnections, by which a person has an overall view of the world associated with epistemic efforts. Another notion of interest here is *connectivity,* which is also related to the structure of the Infoworld. This complex structure looks like a very large network with many communicating nodes. Therefore, connectivity is the ability of information to cross a required number of nodes from its source until it reaches its destination.

In the rest of this section we discuss briefly the following main concepts:

a. **Data.** Any numerical pattern expressed in binary form (0,1). For example: "0000110" is the binary code for "ACK", the acknowledgement character used in data transmission. Data in this (raw) form has no significance by itself [1]. However, in the Infoworld, data are the building blocks of information.

b. **Information.** Data becomes meaningful when accurately interpreted by a data processing (DP) system. The result of such interpretation gives meaning to data. Well-formed data aggregates become meaningful, that is to say they comply with the *semantics* of the system in question. Infoworld users cannot see and need not see data; they only see information: texts, tables, graphs, and so on [2]. From this perspective, and by remembering the notion of actionable knowledge, we regard such semantic information as a *prerequisite* for knowledge.

c. **Knowledge.** In the world of natural sciences, the following is an accepted definition of knowledge: "The objects, concepts and relationships assumed to exist in some area of interest" [3]. Knowledge differs from data or information in the sense that new knowledge can always be created from existing knowledge by the application of logical inference. Such inference may be of the classical "true" or "false" kind or it may contain rules of fuzzy logic in order to accommodate vague attributes of information.

According to original work by Ackoff (1989), a pioneer in the mathematical modelling and analysis of information systems, the mind actually proceeds in small steps from elementary information to wisdom. This is in line with the "information-centric" approach taken in this article. The field of information systems (IS) is now a growing area of ICT research. An interesting connection between IS research and philosophy, due to Dobson (2002), concerns the "useful role" that philosophy can play as "under-labourer" to IS research and practice. The term "under-labouring" is taken from Locke as "clearing the ground a little, removing some of the rubbish that lies in the way of knowledge". Therefore, at this stage, we may conclude that appropriate data, followed by the processing of reliable information and application of inference, can lead to knowledge.

Actionable Knowledge

Let us start this section by considering the two main elements of knowledge in traditional epistemology, namely truth and belief. The problem of defining knowledge in terms of the above two elements began with Plato's view in the *Theaetetus* that knowledge is true belief plus a *logos,* or certification by reason. The fleeting nature of mere true belief was accurately identified by Plato who argued that knowledge is more stable than true belief because it is not easily lost. The well-known *wax tablet paradigm* [Theaetetus, 191c-191e] gives a clear distinction between perception and thought. There, the objects of perception are like a chain of constantly-changing awareness. But, the objects of thought are those objects of perception to which we give a measure of stability by imprinting them on the wax tablets of our minds. The final conclusion seems to be that we cannot define knowledge precicely. But this does not mean that we have not learned anything about what knowledge is like. As Theaetetus admits at the end of his conversation with Socrates, the whole discussion has given birth to far more than he had in him.

Let us continue by considering the following passage from a text entitled *Remarks on Bertrand Russell's Theory of Knowledge* (Einstein, 1944): "In order that thinking might not degenerate into 'metaphysics', or into empty talk, it is only necessary that enough propositions of the conceptual system be firmly connected with sensory experiences and that the conceptual system, in view of its task of ordering and surveying sense experience, should show as much unity and parsimony as possible." Thereafter, Einstein also notes a fateful "fear of metaphysics" which he considers to be a malady and a counterpart to the earlier "philosophizing in the clouds". Further, "that kind of philosophy", he explains, "thought it could neglect and dispense with what was given by the senses".

After reading this passage one feels that Einstein essentially repeats the words of Democritus quoted in the previous section. However, Einstein was wise enough (as Democritus was) to accept, in his later years, "an underlying reality that exists independently of our observations" (Isaacson, 2007). That new view was reflected in a lecture given by Einstein at Oxford, in June 1933, called "On the Method of Theoretical Physics" (Isaacson, 2007). Therefore, we may conclude that there is another way of looking at knowledge which goes beyond the principles of traditional epistemology. Knowledge is not only something that we "possess"; it is also an *interactive process* of increasing our understanding; and such understanding can be achieved through the judicious processing of the information we receive from the world around us.

Life in the 21st century requires us to think whether epistemology should still be based on ancient Greek principles; although there are many modern epistemological problems that Plato would quickly recognise. Perhaps, the most important question is this: How information, in the

age of the Internet, is related to what we perceive as knowledge and what can we do with such knowledge? Philosopher and World War I hero John Macmurray argued that thinking is primarily a physical activity. He believed in action over theory. In his Gifford Lectures Macmurray was brave enough to say that "All meaningful knowledge is for the sake of action, and all meaningful action is for the sake of friendship." Macmurray was more of a public philosopher and, as a consequence, his work has been largely neglected by academic philosophers.

Let us clarify that information processing is *not* the same as understanding; but it could be regarded as a continuous-time feedback process (a special class of stochastic processes) that *can lead* to understanding if information is correctly interpreted and decoded. Information is seen here as the source of knowledge; and, if knowledge is power, then information is the first step towards power. Also, in this article, we consider the human brain as a kind of neural network with complex circuitry and associated memory (Boden, 2006). At any time, the brain is assumed to be capable of selecting the kind of information it needs, store its content and retrieve it for later use. Memory is an important part of this process operating in conjunction with the brain's neuronal circuitry [4].

The knowledge acquisition process is a time-consuming task with a great deal of complexity. Because this process is unstructured, it cannot follow a form known *a priori*, e.g. a linear or an exponential form. After knowledge is conveyed it will have to be stored and then presented into a suitable scheme. Knowledge acquired from external environments, such as the Infoworld, is sometimes incomplete or even erroneous, as previously suggested. Therefore, it should be tested for inconsistencies. This testing will often give rise to further communication in order to clarify existing parts of information and/or elicit more information. Following a recent work of ours on the mathematical modelling of knowledge acquisition (Pentzaropoulos, 2014), we may describe this feedback process as follows:

Process of knowledge acquisition via the Infoworld

[1]: Start of interaction.

[2]: Locate requested data items.

[3]: Interpret data to form information (semantics).

[4]: Apply rules of inference so as to form knowledge.

[5]: Clarify existing knowledge and/or elicit more;

      then, go to [3]; else, continue.

[6]: Store knowledge in an appropriate format.

[7]: Convert knowledge into a representation scheme;

[8]: End of interaction.

We now turn our attention to an often-occurring problem during the knowledge acquisition process, namely the stability of knowledge. This is a serious problem that needs examination.

We start here with *The Statues of Deadalus* [5]. In Plato's work *The Meno,* Socrates refers to the legend (*mythos*) of the sculptor Daedalus who created impressive, life-like statues. Socrates was probably the first philosopher to realize that knowledge is more valuable than true belief or opinion because, like the Statues of Daedalus, simple opinions tend to fly away [Meno, 97c

- 98a]. True beliefs are still useful but cannot stay in their place unless they are tethered to the ground by what Socrates calls a logical explanation (*aetias logismos*). Socrates seems to suggest here that the man who really knows the way to Larissa is that who has *actually* travelled himself the distance from Athens to Larissa. Thus, Socrates seems to support the idea that knowledge, often but not always, requires experiencing something by oneself. In our time, we call that kind of knowledge "first-hand" experience.

Today, one can travel from Athens to Larissa without *a priori* knowledge of the details of the route. Modern cars are fitted with global positioning systems (GPS) that provide instant information about the details of the route as the car moves along the highway. Therefore, it is now possible to get from point A to B without the need to gather detailed information before the journey. Knowledge, here in the form of experience, is constructed *dynamically* over time. When the journey ends, the driver will have accumulated all knowledge associated with the route. He can use the same knowledge in a subsequent travel on the same route without the need of a GPS, as long as he can remember the details (the memory problem). The GPS device is an example of a handy expert system that works on the principle of online knowledge extraction.

So far, we may conclude that information does *not* equate to knowledge. Therefore, information processing is *not* the same as understanding; but it can be argued that reliable information combined with careful processing may lead to informed decisions. We also note that, as evidence shows, sensory knowledge is not always reliable. Thus, knowledge extracted through information processing can sometimes be unreliable. This happens when the source contains errors. Such errors, for instance, might be distorted binary numbers or logical errors when a sequence of statements breaks down. Whenever that happens, knowledge becomes unstable. The problem of knowledge stability is correlated with the problem of reliable information if one accepts, as we do in this article, that information is a *prerequisite* for knowledge.

The problem of information reliability can be examined both from an epistemic and systemic point of view. In epistemology, the following example is given (Pritchard, 2008). Suppose a visitor is trying to find his way to the nearest restaurant in an unfamiliar city. Suppose, also, that the map used is unreliable. Eventually, the visitor would notice that none of the landmarks corresponded to where they ought to be. The confused visitor would realize that his map was unreliable and that he would have difficulty in finding his way. Still, he might reach his goal entirely by chance; but epistemologists generally agree that knowledge gained by chance is not stable. Lack of reliability results in a feeling of confusion, as in the above example. Confusion is also a sign of uncertainty. From a systemic point of view, uncertainty is a manifestation of entropy [6].

Entropy has its roots in physics, particularly in thermodynamics. Generally, the entropy of a real system is defined as a measure of its intrinsic uncertainty. This notion has become familiar in our time thanks to the pioneering works of Claude Shannon and Norbert Wiener. Also, in a very different field, known as economics of information, Arrow (1984) defines information as the reduction in system uncertainty. Since entropy distorts information content, this often leads to unstable knowledge and away from the right decisions. The discussion so far points to the need of obtaining reliable information which, if achieved, leads to stable knowledge.

The relationship between "system" entropy *[E]* and its stability *[S]* can be visualized as follows. When *[E]* is near its minimum, the system in question is perfectly stable. When *[E]* progresses in moderation, *[S]* follows a negative exponential form, until it reaches its upper tolerable limit known as the *plateau.* If *[E]* progresses further, the system leaves its stable region, becoming unstable. In the absence of control over entropy, stability can fall sharply.

The "system" mentioned above in general terms can be "mapped" to the Infoworld of this article. The elements transmitted across the Infoworld are messages containing words, symbols, graphs, and so on. These messages can typically be measured by their information content. Messages may arrive in order but sometimes their order might have changed due to random fluctuations. In the first case, messages retain their meaning while in the second case part of their meaning is lost. The latter case is troublesome since, in the mind of the receiving user, information appears as a random aggregation of elements. In this case we have a typical appearance of high entropy. The presence of high entropy is clearly undesirable and must therefore be minimized.

We may conclude that reliable information obtained from the Infoworld leads to a greater stability of knowledge. Stability requires reliable information which can be achieved at the expense of uncertainty. The latter can be described as a manifestation of system entropy. Thus, by reducing entropy, uncertainty is also reduced, and the flow of information approaches steady state. In that state, knowledge is considered stable. Entropy minimization is a complex problem, which in certain cases cannot be solved. Real-life systems like business environments and organizations with many workers often exhibit a circulatory movement of information that creates confusion. Such movement typically has the form of a *feedback* which contributes to an increase in entropy.

Norbert Wiener, the founder of Cybernetics, argued that any increase in information will always increase system stability, whether this information is communicated by a living being or a machine (Wiener, 1950). The ancient Greek word "homeostasis" was seen by Wiener as a kind of steady-state applicable to both humans and machines.

Concluding Remarks

Below we summarize the main findings of this article, as in remarks 1 to 3, and then propose a transition concerning a new possible definition of knowledge.

Remark 1. Information in digital or physical form occurs naturally. Data are considered as the building blocks of the Infoworld. Correct interpretation of data leads to semantic information. Knowledge follows by applying to information appropriate rules of inference. Further, knowledge acquisition can be regarded as a continuous-time feedback process.

Remark 2. Practical "know-how" knowledge is often neglected in mainstream epistemology. Actionable knowledge, as discussed here, has the property of extrinsic value, especially economic value. The latter property should be seen as an essential element of present-day information society.

Remark 3. Knowledge may often become unstable. Reliable information helps reduce the phenomenon of entropy. Entropy minimization, when achieved, implies less uncertainty and therefore greater knowledge stability. This, in turn, can lead to more informed decisions.

In classical epistemology "true belief" is taken to be the basis of knowledge. This view dates back to ancient Greece and it appears mainly in Plato's works *Theaetetus* and *Meno*. But what if "information" was the basis of knowledge? Included here is any kind of information; not only information transmitted in digital form, but also information we usually get by reading a book or newspaper or information we get as a result of a conversation with a friend or colleague. Following this "information-centric" view, we propose the following transition:

Knowledge: {true belief *plus* logos} => {reliable information *plus* inference}

Such a transition, if accepted, signifies a major departure from the roots of classical epistemology and from a substantial corpus of subsequent research. There is a benefit in turning away from the "true belief" model in favour of the "reliable information" model in the sense that knowledge no longer needs its old psychological basis. Because information occurs naturally in the physical world, using reliable information as the building block of knowledge makes better sense in this digital world of ours. Of course, we must also re-consider uncertainty. But this consideration is far from new: "all scientific knowledge is a series of statements with varying degrees of uncertainty" (Feynman, 1998).

The kind of transition suggested above might prove beneficial in our time. Given that, in a modern society, information is widely recognized as an asset, in fact an asset with economic value, it follows that knowledge can also have economic value. This, we argue, is particularly true of actionable knowledge. Thus, it would be helpful if knowledge was accepted as a "product" of information that can enrich both our economic and social status. The emerging knowledge economy and society is based on intellectual capital, a new form of capital generated by knowledge workers.

Earlier in this article, we noted the power of new technologies and their ubiquity in everyday life. The developments taking place within the whole ICT field will eventually alter our vision of the world, save time and resources, and provide opportunities for more innovation and economic prosperity. The same developments are also helping philosophy, especially philosophy of technology, become a maturing field of inquiry and possibly contribute to social change. With that observation in mind, we can still accept the time-honoured tradition, e.g. that "it is not the purpose of philosophy to give us knowledge about the world but to give us understanding of ourselves (Khashaba, 2010). We cannot see any conflict between understanding the "world" and "ourselves": these two entities are strongly correlated in present-day information society, as we have tried to demonstrate in this article. Of course, we recognize that the emerging field of the *philosophy of information* still has to make a clear mark on the epistemological landscape [7].

We end this article with a further remark from the field of natural sciences. James Lovelock, a prominent member of the Royal Society, seems to regard information as a prime substance of the natural world (Lovelock, 2015). In his book *A Rough Ride to the Future,* Lovelock writes: "Modern physicists who have thought hard and long about the nature of the universe seem to say that everything in the end is *information* – another world, like intelligence, which we think we can define but which so far eludes our conscious minds."

Notes

[1] Another view of data: "With the explosive increase in the quantities of data in modern science, the individual *datum* becomes decreasingly relevant. The word is used as a singular since it is merely the aggregates of data, considered as an indistinct mass like butter." Howard, Philip. (1979). *Data,* in: *The Bedside Book,* Julian Shuckburgh (Ed.), Windward, pp. 44-47.

[2] It is interesting to note that information, like data, is also a singular since no plural form exists in English. However, plural forms exist in (modern) Greek and in other European languages.

[3] For example, see: free online dictionary of computing (www.foldoc.org), hosted at Imperial College, University of London.

[4] Modern Biology has shown that the human brain contains several billion neurons and trillions of synapses. Artificial neural networks (from AI research) come nowhere near those figures.

[5] Deadalus created very realistic, life-like statues, with open eyes and the limbs in motion. Thus, according to the legend, his statues had to be chained to the ground to prevent them from running away.

[6] Greek prefix *(εν-)* plus *(τροπή)*. The result is the complex word entropy.

[7] Robert Doyle defines philosophy of information as a new philosophical method grounded in physics, biology, neuroscience, and information science. See also: [http://www.informationphilosopher.com/about/]

Acknowledgements

References

Ackoff, Russell, L. (1989). "From Data to Wisdom", *Journal of Applied System Analysis,* 16: 3-9.

Argyris, Chris (1996). "Actionable knowledge: design causality in the service of consequential theory", *Journal of Applied Behavioural Science,* 32 (4): 390-406.

Arrow, K.J. (1984). The Economics of Information. Cambridge, Mass.: Belnap.

Blackburn, Simon (Ed.) (2008). *The Oxford Dictionary of Philosophy,* Oxford: Oxford University Press. See under "epistemology".

Boden, Margaret A. (2006). *Mind as Machine: A History of Cognitive Science*, in 2 volumes. Oxford: Clarendon Press.

Dobson, Philip J. (2002). Critical realism and information systems research: why bother with philosophy? Information Research, 7 (2). Available from: [http://InformationR.net/ir/7-2/paper124.html]

Einstein, Albert (1939). "Message in the Time-Capsule". In: *Albert Einstein's Ideas and Opinions*, see page 18. Originally published in *World's Fair.* Reprinted in 2015. London: Souvenir Press Ltd.

Einstein, Albert (1944). "Remarks on Bertrand Russell's Theory of Knowledge" In: *Albert Einstein's Ideas and Opinions*, page 23. Originally published in *The Philosophy of Bertrand Russell,* Vol. V. of "The Library of Living Philosophers", Edited by Paul Arthur Schilpp, Tudor Publishers. Reprinted in 2015. London: Souvenir Press Ltd.

Feynman, Richard, P. (1998). *The Meaning of it All,* London: Penguin.

Floridi, Luciano (2014). The Fourth Revolution: How the Infosphere is Reshaping Human Reality, Oxford: Oxford University Press.

Isaacson, Walter (2007). Einstein: *His Life and Universe,* London: Simon & Schuster.

Khashaba, D.R. (2010). Socrates, Plato, and Science. *Philosophy Pathways,* Issue Number 157, Part III.

Klempner, Geoffrey (2007). *The Possible World Machine*. E-book available at: [http://www.philosophypathways.com/download/Possible_World_Machine.pdf]

Lovelock, James (2015). *A Rough Ride to the Future,* London: Penguin Books.

Mansell, R. and Tremblay, G. (2013). *Renewing the Knowledge Societies Vision for Peace and Sustainable Development,* Geneva: UNESCO.

Pentzaropoulos, Georgios C. (2014). "Conceptual Framework for Modelling Knowledge Acquisition across Internet Servers", *Advanced Modelling and Optimization,* 16 (1): 199-210.

Pritchard, Duncan (2008). *What is this Thing Called Knowledge?* London: Routledge.

Wiener, Norbert (1950). *The Human Use of Human Beings.* The Riverside Press: Houghton Mifflin Co.